Chemical Engineering

WITH CHEMICAL & METALLURGICAL ENGINEERING

MAY 1949

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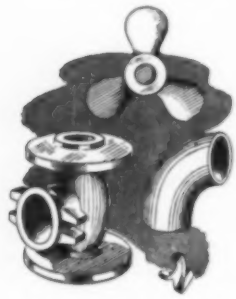

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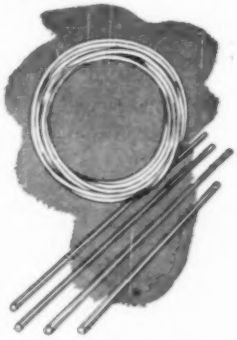

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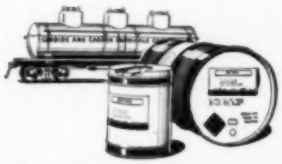

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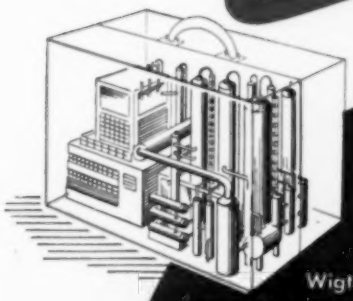

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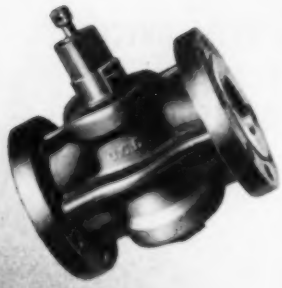

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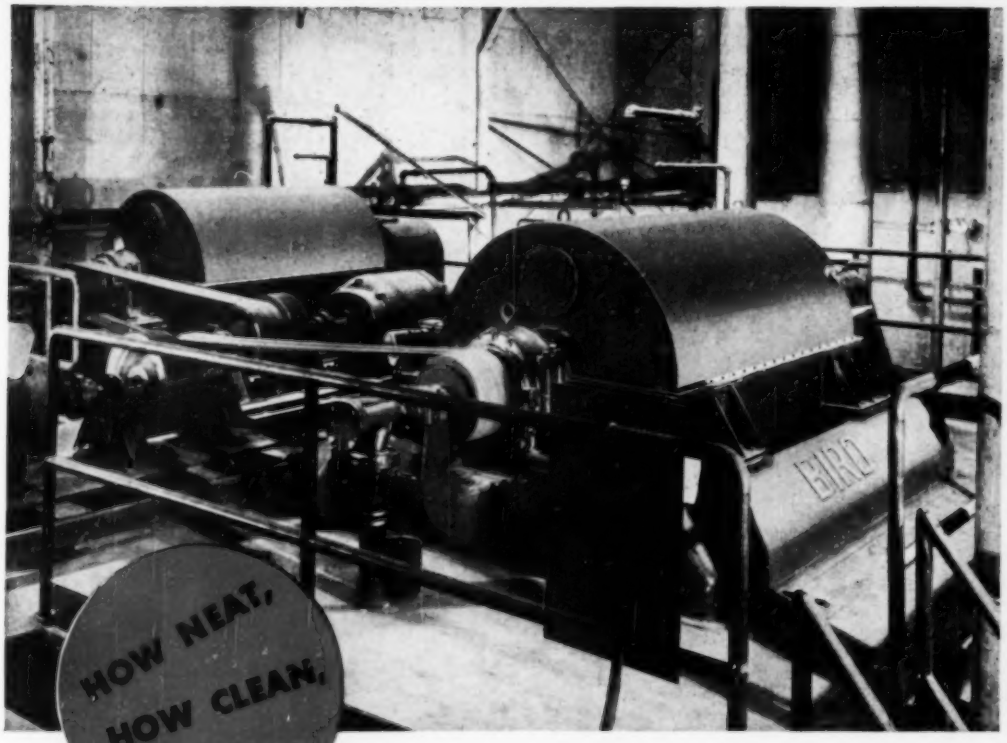

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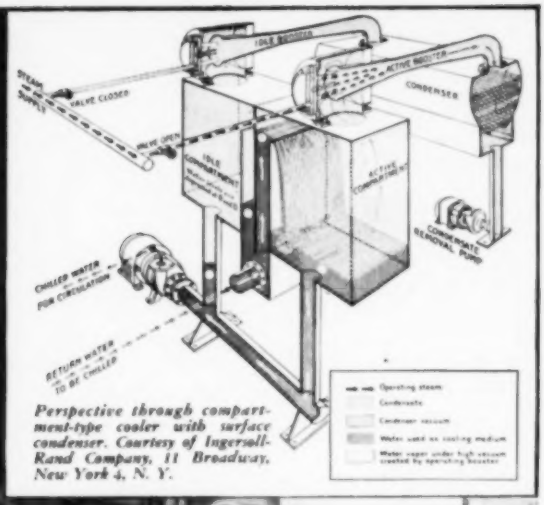
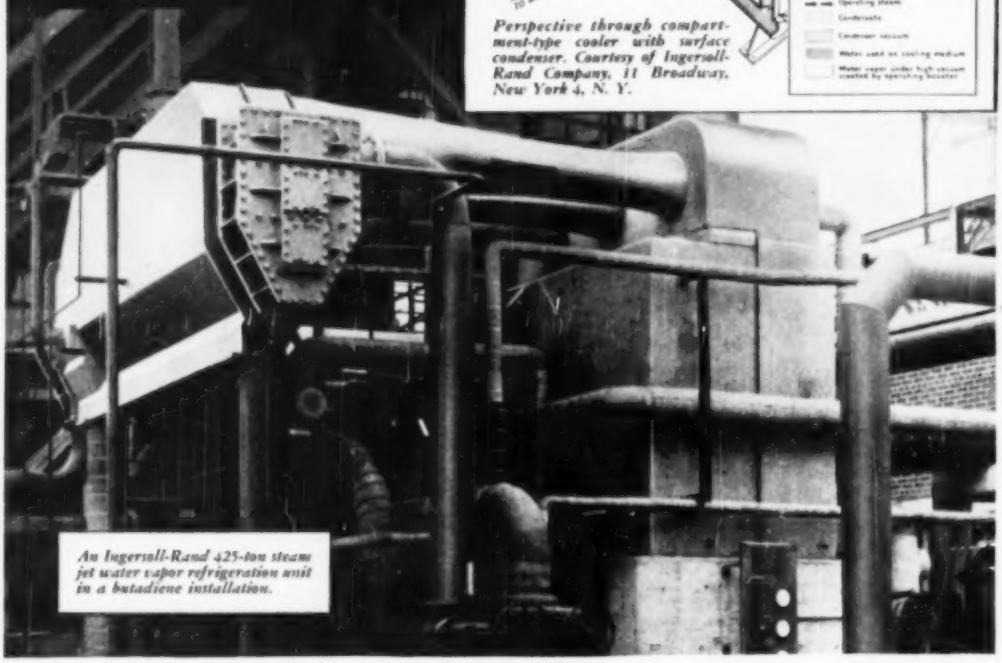


Perspective through compartment-type cooler with surface condenser. Courtesy of Ingersoll-Rand Company, 11 Broadway, New York 4, N. Y.



An Ingersoll-Rand 425-ton steam jet water vapor refrigeration unit in a butadiene installation.

Large steam jet ejectors, while based on a relatively old principle, are today utilized to produce refrigeration. In its new dress, a jet of live steam at 2 psig or more darting in a properly-designed venturi tube greatly reduces the pressure over warm water. The jet also removes water vapor, thereby maintaining the vacuum and lowering the temperature of the water to that at which it boils, which may be as low as 35° F. Such coolers are in use today in many industries, such as:

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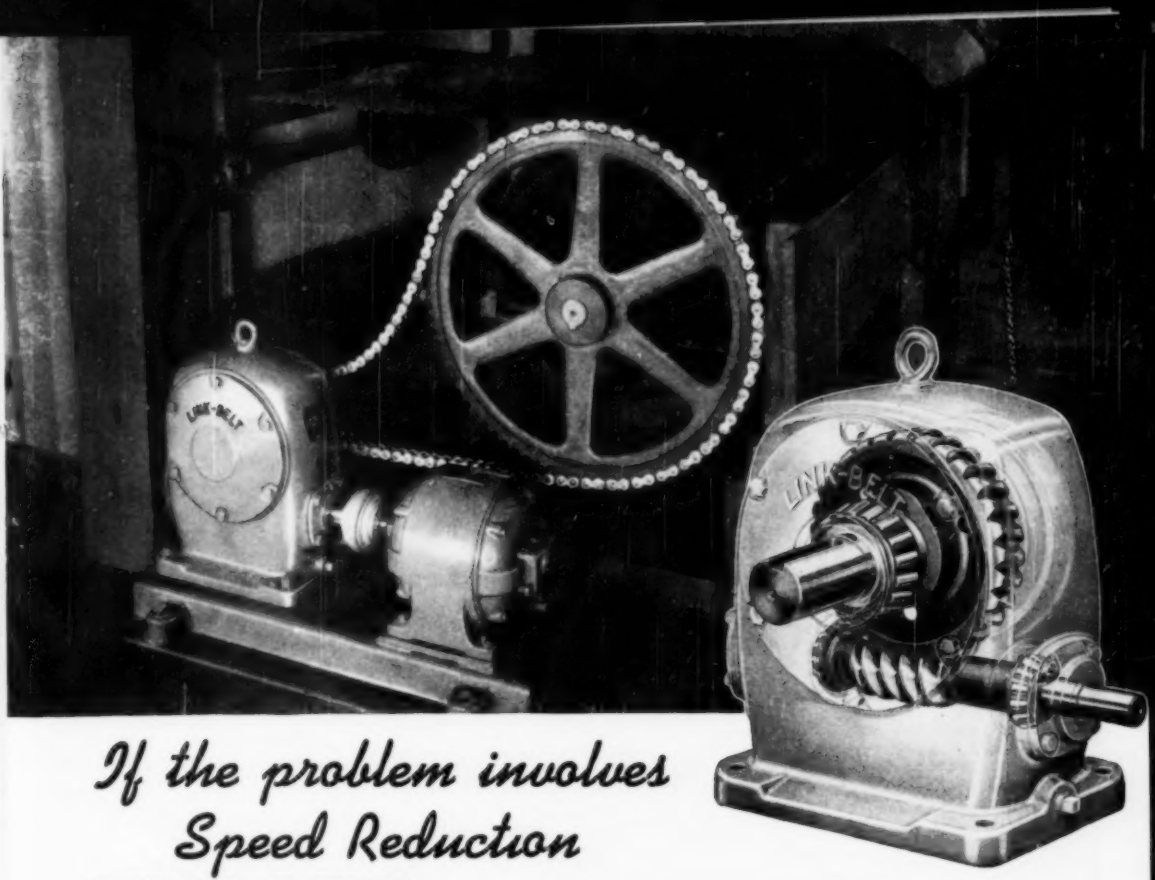

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Utah screens operate at 3600 vibrations per minute on 60 cycle current, 3000 on 50-cycle, 1500 on 25-cycle current. Straight-line motion.

Hinged door with weighted arms makes cloth inspection easy. Quick-opening covers provide access for tensioning screen cloth.

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Almost no maintenance is required! Electro-magnetic principle requires no rotating, sliding or striking parts. Nothing to lubricate.

Screens Met

SODA ASH SIZING

BLINDING of fine screen mesh made this job of soda ash sizing a difficult one. Then this processor installed the battery of three *Utah* electric screens shown at left. Result: Blinding became a negligible consideration . . . maintenance was reduced, too!

Soda ash is only one of many materials screened successfully with *Utah* electric screens. These modern Allis-Chalmers screens are flexible enough in operation to handle a wide range of fine, granular materials from 10 to 48 mesh (dry) or 65 mesh (wet).

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Get more facts about *Utah* screens from the A-C representative in your area. Or write for **Bulletin 07B7044.**

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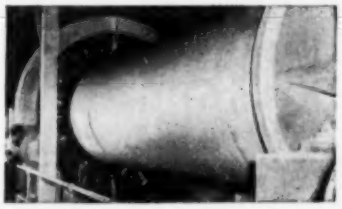

GRINDING Silex lined pebble mills with flint pebble grinding media eliminate iron contamination, are widely used for silica reduction. Allis-Chalmers builds a complete line of pebble mills with diameters 5 to 8 ft; lengths 10 to 24 ft. Installation shown above is in a chemical processing plant.

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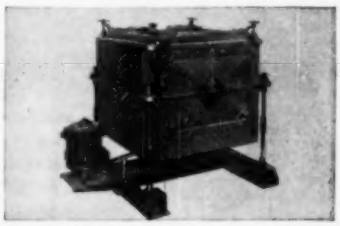

SIFTING Heavy Duty Low-Head Gyratory Sifter has series of interchangeable sieves, 3 to 7 sieves high for 2 to 8 separations . . . can handle two materials at same time. Has large capacity per sq ft of cloth area. Compact and dust-tight. **Bulletin 06B6124A.**

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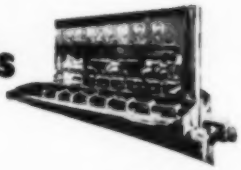
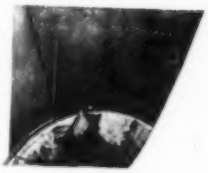
...blunt the teeth of Hungry Acids





In unnumbered processing plants across the country, sheet lead plays a vital role in keeping acids under control. Because, among other unique properties given lead by nature, is *stern resistance to corrosion.*

* *

It is this innate ability to blunt the teeth of hungry acids, coupled with several of lead's other "abilities"—adaptability, workability, durability and availability—that makes the use of lead a virtual "must" as a lining for tanks, tubs and vats in which corrosive liquids are handled, moved or stored.

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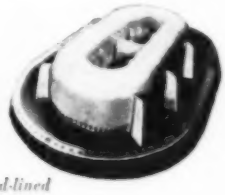

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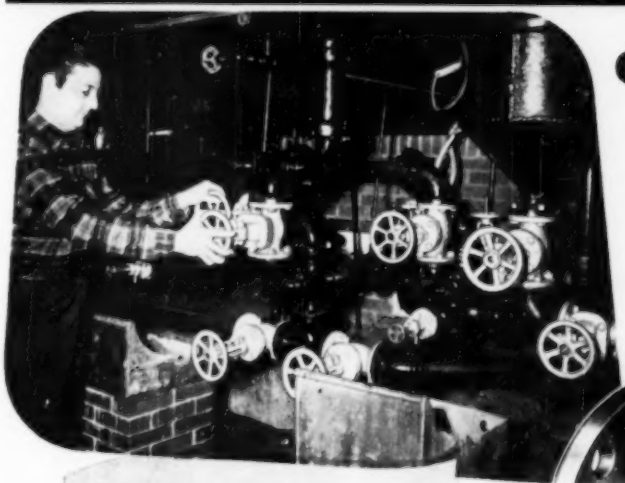


Aloyco Stainless Steel Valves in the Acid Plant of the Daugherty Refinery division of L. Sonneborn Sons, Inc. at Petrolia, Pennsylvania.

Aloyco Flanged Gate Valve, No. 111, 150 lb., ½" to 12" inclusive. Available in 18-8S, 18-8SMo, Aloyco 20 and other corrosion-resistant alloys.

"ONE of the most interesting observations we have made insofar as Aloyco Valves are concerned is that the maintenance to this date has been nil. In two years of service we have never lost a minute of operating time with Aloyco Valves. I would heartily endorse Aloyco 20 Valves for similar services". The remarks are those of Mr. G. H. Miley, Acid Plant Superintendent of the Daugherty Refinery, Petrolia, Pennsylvania, a division of L. Sonneborn Sons, Inc.

The Aloyco Valves here are used in the acid control lines of their contact H_2SO_4 plant. They handle 93% and 98% H_2SO_4 and oleum in temperatures ranging from 115° to 150°F. This Company formerly used iron and steel valves with alloy trim for the same application. Aloyco Valves in this particular installation have been in service several times as long as any previous valves.

Let our sales engineers study your requirements.

ALOYCO

STAINLESS STEEL
VALVES AND FITTINGS

GATE, GLOBE, Y, CHECK, TANK, SAMPLING AND V-PORT VALVES
SCREWED AND FLANGED FITTINGS

ALLOY STEEL PRODUCTS COMPANY, INC.

1301 WEST ELIZABETH AVE. • LINDEN, N. J.

SALES OFFICES: ATLANTA, CHICAGO, HOUSTON,
LOS ANGELES, NEW YORK CITY, PITTSBURGH, WILMINGTON, DEL.

MEASURES EXACT QUANTITY

THEN SHUTS OFF AUTOMATICALLY

For formula-perfect batches time after time—automatically—simply set quantity of liquid desired, open valve, and this Neptune Auto-Stop meter does the rest. Stops waste of valuable ingredients, prevents overdilution with water that must later be removed. Think of the savings possible in your own batch mixing!

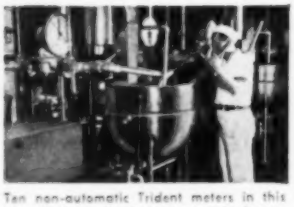
LET'S LOOK AT SOME CASES:

Five Trident Auto-Stop meters accurately measure water, starch water, and clay slurry into mixers in this mid-western plant.

Hundreds of Neptune Auto-Stop meters like this control moisture of concrete in ready-mix plants, and of sand in foundries.

Water is automatically measured into washers by Neptune Trident Auto-Stop meters. Other Neptune meters measure soap, cleaning fluids, brine.

Long Island bottler maintains product uniformity by accurately metering both water and liquid sugar into syrup mixing kettles. At left is 1" Auto-Stop; at right is 2" Auto-Stop.



Ten non-automatic Trident meters in this New York candy plant measure both corn syrup and liquid sugar the easy way—right into the kettles.

NOW TAKE A LOOK AROUND *Your Plant*

Ask for Industrial Metering Bulletin 566-4

NEPTUNE *liquid* METERS

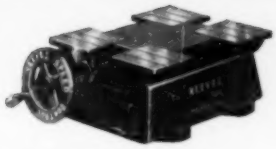
NEPTUNE METER COMPANY
50 WEST 50TH STREET, NEW YORK 20, N. Y.

Branches: Atlanta, Boston, Chicago, Dallas, Denver, Kansas City, Mo., Los Angeles, Louisville, Philadelphia, Portland, Ore., San Francisco, and Long Branch, Ontario

15-4

Reeves Vari-Speed Motor Pulley

converts any standard constant speed motor to a low-cost stepless variable speed drive . . .

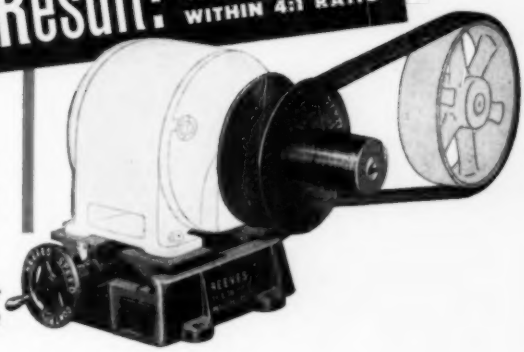


1. REEVES Motor Base provides sliding platform for motor. Handwheel or push-button control increases transmitted speed by moving motor toward driven machine, decreases speed by reversing the operation.

2. Disc Assembly connects directly to motor shaft. Assembly consists of two facing cone-shaped discs—one sliding laterally—and compression spring for mounting on motor extension shaft.

3. Special V-Belt hooks up unit with driven machine. Belt fits between discs and over pulley on power input shaft of driven machine. Belt is adjusted to minimum center.

Result: INFINITELY VARIABLE SPEED WITHIN 4:1 RATIO



Unit instantly delivers any desired speed over entire range and maintains that speed without fluctuating even a fraction of an rpm.

The REEVES Vari-Speed Motor Pulley is the easiest, lowest-cost method of converting a machine with fixed speeds into a highly versatile unit of infinitely variable speed adjustability. Thus equipped, it can handle a wider range of work, better, faster and more economically, because machine speed can be changed instantly and accurately—without shutdowns—to meet the needs of every operation and every operator, *under every changing condition.*

This REEVES unit forms the actual driving element between motor and driven shaft . . . eliminates all auxiliary equipment such as chain drives, gears, belts, etc., . . . requires virtually no more space for installation than any standard belt or chain drive. It is built in eleven sizes, transmitting from ⅛ to 15 hp, over speed ratios from 2¼:1 to 4:1, inclusive.

The complete line of REEVES Speed Control equipment also includes two other basic units, the Variable Speed Transmission and the Motodrive, which are offered in the widest selection of designs, sizes, capacities and speed ratios—with handwheel, push-button or entirely automatic controls.

REEVES units have proved their ability to speed production, cut cost and increase profit in more than 260,000 widely diversified industrial applications . . . are listed as standard equipment on over 2,100 different makes of modern machines.

An experienced REEVES Speed Control specialist will be glad to work with you in selecting the units best suited to your needs. Write today, arranging an interview, and ask for the comprehensive 114-page catalog CE7-450A.

REEVES PULLEY COMPANY • COLUMBUS, INDIANA

Recognized Leader in the Specialized Field of Speed Control Engineering

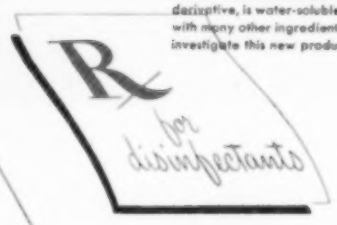
ACCURATE • VARIABLE

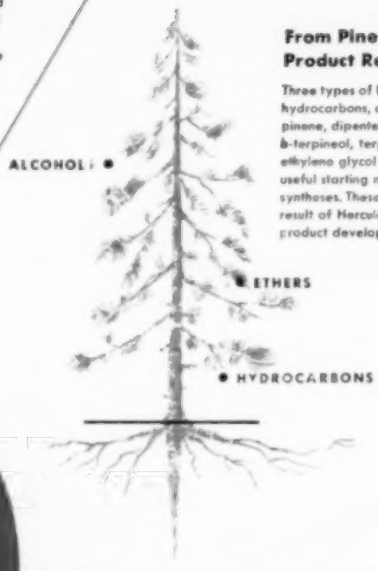
Reeves Speed Control

GIVES THE RIGHT SPEED FOR EVERY JOB!

High Phenol Coefficient

Are you seeking a chemical material with a high phenol coefficient as well as surface active, fungicidal and bactericidal properties, and the chemical attributes of primary amines? Rosin Amine D Acetate, a new Hercules rosin derivative, is water-soluble, and is compatible with many other ingredients. Why not investigate this new product now?





From Pine Tree to Product Research

Three types of Hercules' terpenes—hydrocarbons, alcohols, and ethers—pinene, dipentene, α-terpineol, β-terpineol, terpinyl methyl ether, terpinyl ethylene glycol ether offer a variety of useful starting materials for chemical syntheses. These terpenes are the result of Hercules' extensive product development activities.

Special Resin for High-Quality, Heat-Set Inks

Hercules "Pentalyn" K was developed specifically for high-quality, high-gloss, heat-set printing inks. High softening point . . . fast solvent release . . . maximum solubility . . . minimum viscosity. It is stable with reactive pigments, has good flow and pigment wetting characteristics.

Latest Data on CMC (Cellulose Gum)

New, 12-page book on "Hercules" CMC gives latest information on this water-soluble cellulose gum, describes newest uses. Among important uses described are foods, pharmaceuticals, and cosmetics—where CMC can be used for viscosity control, for emulsion stabilization, as an ointment base, as a water-soluble film former, or as a suspending agent.

"PENTALYN" AND "HERCULES" ARE REG. U. S. PAT. OFF.

HERCULES POWDER COMPANY

822 Market Street, Wilmington 99, Del.

Send technical data ☐ test samples ☐ all

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Title _____

Company _____

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GC9-2

Are You Employing the Best Techniques for Uniform and Controlled Heating?

Foster Wheeler Process Heating Systems with *Dowtherm Vaporizers*

edible oil deodorization

oil bodying

fatty acid distillation

resin processing

esterification

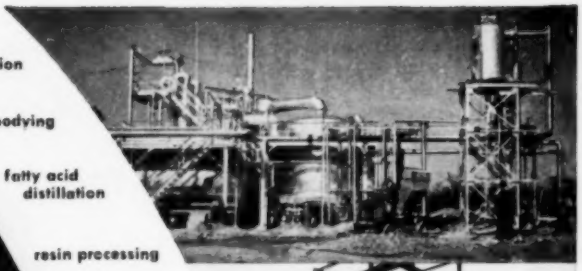
phthalic anhydride

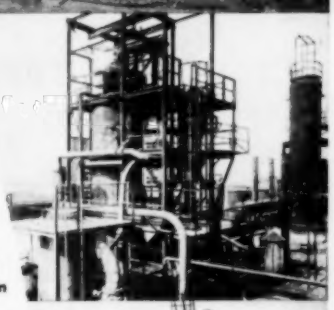
castor oil dehydration

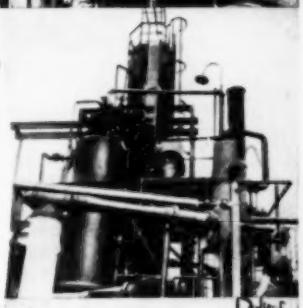
sulphuric acid concentration

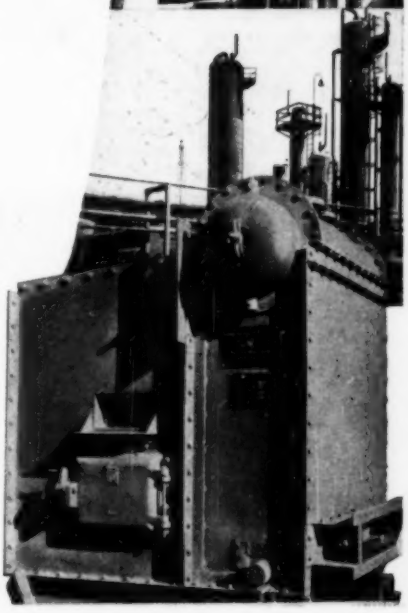
catalyst heating and regeneration

hypersorption









Manufacturers of Heat Exchanger Equipment for over 50 years

Foster Wheeler, long recognized as one of the world's foremost builders of complete processing systems, manufactured heat exchanger equipment since 1898. This vast background of engineering and manufacturing service to the processing industry places Foster Wheeler in an unique position. It assures proper design and construction of equipment and complete systems for those new processes demanding high and closely controlled temperatures.

Built Earliest Systems Employing Dowtherm

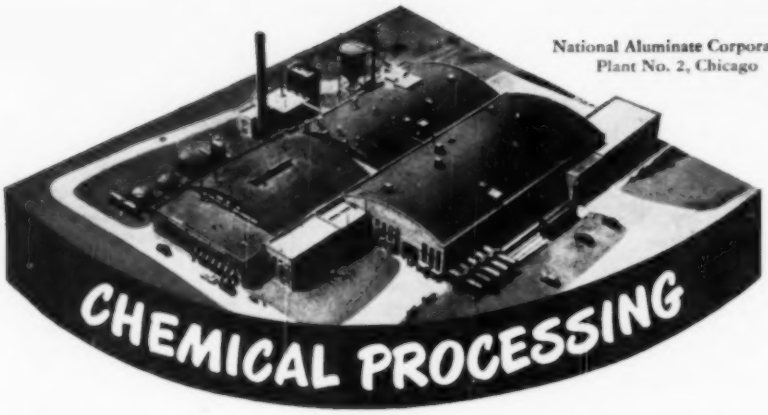
Foster Wheeler was the first to design, engineer, and construct heat exchanger equipment, vaporizers, and complete systems using Dowtherm, the heat transfer medium for high temperatures. Dowtherm heating has improved product quality and reduced operating costs in such widely varied fields as foods, fabrics, plastics, rubber, paints, and varnishes.

Proved by Many Years of Service

Foster Wheeler-constructed plants employing Dowtherm heating have been operating with complete satisfaction since 1932. During that time Foster Wheeler also built hundreds of vapor generators used in conjunction with complete systems. Foster Wheeler installations range from laboratory models to plants yielding as much as 150,000,000 pounds of fatty acids per year.

FOSTER WHEELER CORPORATION • 165 Broadway, New York 6, N. Y.

FOSTER WHEELER



National Aluminate Corporation
Plant No. 2, Chicago

Multi-Stage Continuous Drying Systems at NATIONAL ALUMINATE CORPORATION

Emphasize The Versatility of GAS

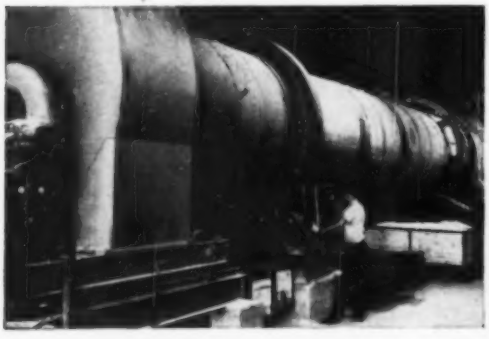
DESICCATING SYSTEMS, integrated with the chemical processes help National Aluminate Corporation meet the increasing demand for its synthetic zeolite water softening compound.

Three continuous multi-zone ovens, heated by GAS, are automatically controlled to provide the exact zone temperature for every stage of the operation. This automatic controllability of GAS permits regulation of the oven temperatures for the type of product being dried.

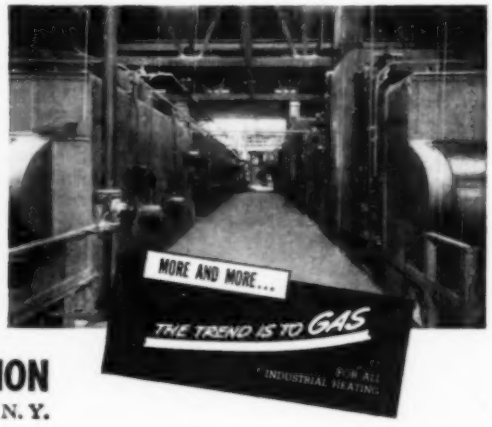
In addition to the oven-drying system, National Aluminate Corporation depends on GAS for reducing the moisture content of a catalyst used in producing aviation gasoline. The catalyst passes through the continuous Gas-fired multi-stage ovens, and then is finally processed in a rotary drying kiln equipped with luminous flame GAS burners.

These two applications of GAS demonstrate the most efficient utilization of the fuel in continuous, high-speed drying. Flexible Gas Equipment offers many an opportunity for economical heat processing in chemical manufacturing. You'll find it's worth investigating.

The moisture content of a chemical catalyst is reduced in this 65-foot kiln equipped with North American luminous flame GAS burners.



Zeolite is dried in these multi-zone Proctor & Schwartz continuous Gas ovens.



AMERICAN GAS ASSOCIATION
420 LEXINGTON AVENUE, NEW YORK 17, N. Y.

AT LAST! 6-Point Recording on a Single Round Chart

THE NEW MULTI-RECORD DYNALOG*

Employing only one measuring system, the new Foxboro Multi-Record Dynalog gives up to 6 clean-cut records in as many different colors on one convenient *round* chart. The ingenious, foolproof switching arrangement provides recordings in sequence every 6 seconds—so close that the record of each measurement appears as a continuous line. The record colors positively will not run together.

Like all Dynalog Electronic Instruments, balancing from any measurement point is entirely *stepless* and continuous. Its combination of accuracy, speed and sensitivity is unequalled.

The Multi-Record Dynalog is available for measuring several temperatures or other process variables. Send for Bulletin 428. **The Foxboro Company, 16 Neponset Avenue, Foxboro, Mass., U. S. A.**

UNIQUE ADVANTAGES!

1. Round Chart simplifies operations. You can check records faster, easier and better on the familiar, compact round chart of the new Multi-Record Dynalog. No yards of paper to insert, remove and spread out. Practically continuous lines to follow. Up to 6 distinct colors. Charts occupy less space . . . cost less to use.

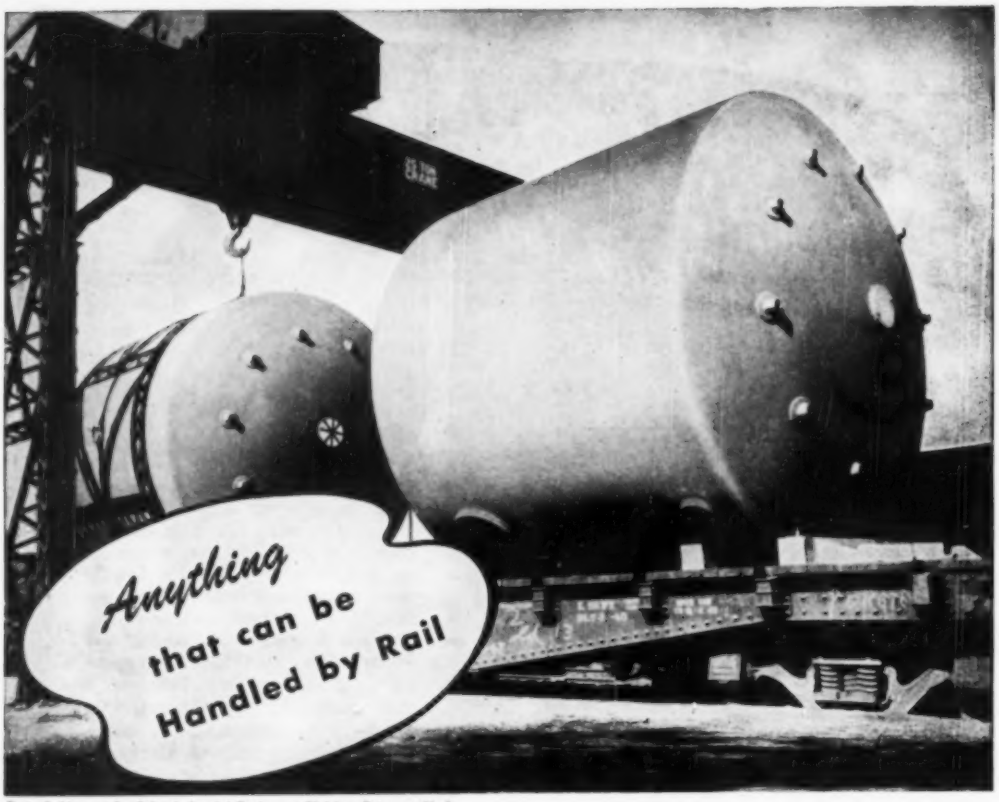
2. Round Chart standardizes operations. You can order, stock and use the identical form of chart as used on other types of process instruments.

3. Multi-Record Dynalog saves space.

* Reg. U. S. Pat. Off.

Another FOXBORO FIRST

Reg. U. S. Pat. Off.



Part of shipment for Belco Industrial Equipment Division, Paterson, N. J.

. . . can be RUBBER LINED at Manhattan

If you are hesitating to rubber line your process equipment because of its size or complexity, consider the facilities of Raybestos-Manhattan . . . "Giant"—"Huge"—"The World's Largest"—are terms rightfully applied to job after job that goes through the Passaic plant. Some Manhattan tank lining jobs are so large, their entire railroad routes have to be checked for height and width clearance. Some have to be transported in sections . . . But nothing seems to overtax Manhattan ingenuity in handling the most difficult problems.

You can place complete confidence in Manhattan's tank lining capacity. The largest of a battery of vulcanizers is a mammoth chamber 15 ft. in diameter, one of the largest made. It accommodates anything that can be shipped on a railroad flat car. Other equally notable handling facilities insure careful transportation and thorough workmanship. More than 40 years rubber lining experience add to your assurance of quality.

Enduring, dependable protection of your equipment and processes from corrosion and contamination is sound economy. Call a Manhattan Rubber Lining Engineer to "talk it over" at no obligation.

Keep Ahead with Manhattan

MANHATTAN RUBBER DIVISION — PASSAIC, NEW JERSEY

RM

RAYBESTOS-MANHATTAN, INC.

Manufacturers of Mechanical Rubber Products • Rubber Covered Equipment • Radiator Hose • Fan Belts • Brake Linings • Brake Blocks • Clutch Facings • Packings • Asbestos Textiles • Powdered Metal Products • Abrasive & Diamond Wheels • Bowling Balls

50 YEARS OF SERVICE

BASIC CHEMICALS

GC

FOR AMERICAN INDUSTRY

ACIDS
ALUMS
SODIUM COMPOUNDS
PHOSPHATES
FLUORINE DERIVATIVES
OTHER INDUSTRIAL CHEMICALS
REAGENTS
FINE & SPECIAL CHEMICALS

It takes scores of steady customers to keep a company climbing through the business peaks and valleys of 50 years. Satisfying them means providing a lot of service of the right kind at the right time.

In 1899, the founders of General Chemical believed in this when they combined a dozen small companies into one well-knit organization. Today, that concept of General Chemical service has resulted in more than 90 producing and distributing facilities in centers of commerce from coast to coast.

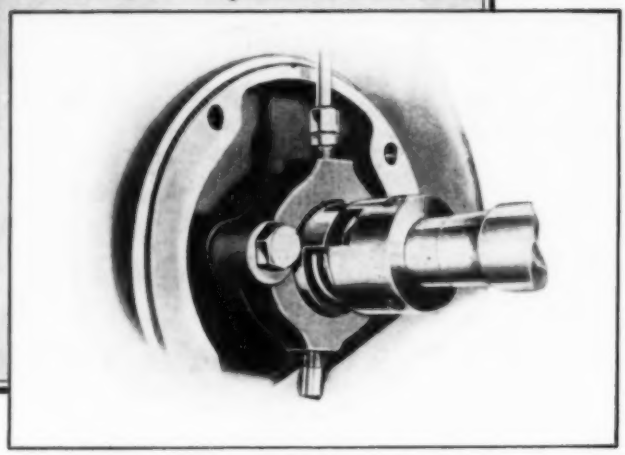
In research, engineering, production, and in sales, everything is done that can be done to serve you well. Remember this when you specify General Chemical—first for Basic Chemicals for American Industry.

GENERAL CHEMICAL DIVISION
ALLIED CHEMICAL & DYE CORPORATION
40 Rector Street, New York 6, N. Y.
OFFICES IN PRINCIPAL CITIES FROM COAST TO COAST

When Packing Against

CORROSIVE LIQUIDS . . .

you can depend on Worthington Worthite Pumps equipped with Type EA Mechanical Seals



Worthington Type EA Mechanical Seal for Worthite Type CG Chemical Pumps. Three sizes of seals for 23 sizes of pumps.

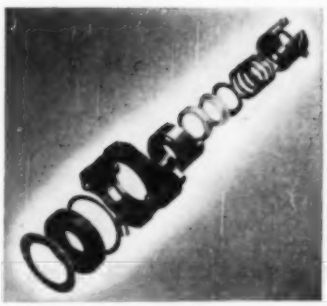
If you have been running into trouble with your stuffing boxes and packings, it's time to consider Worthington Type EA Mechanical Seals. They're especially designed for Type CG Worthite Pumps up to 1200 gpm capacity.

These seals have given outstanding performance in corrosive liquid service. The following distinctive features tell you why:

No stuffing box . . . no packing to replace. Outside assembly . . . easy to apply, simple to repair. No parts churning in acid. All parts made of corrosion resisting material. Pressure is adjustable without dismantling. Single coil Worthite spring. Tongue and groove drive.

Write for BULLETIN W-350-B-10.

For complete details about this Worthington contribution to better pumping of corrosive liquids and further proof that *there's more worth in Worthington* write for Bulletin W-350-B-10. *Worthington Pump and Machinery Corporation, Centrifugal Pump Division, Harrison, N. J.*



Exploded view of Worthington Type EA Mechanical Seal shows simplicity of this tested solution to tough stuffing box problems.

CGH-1A Worthite pump equipped with Worthington Mechanical Seal in a Southern chemical plant.

WORTHINGTON

CG-6

THE WORLD'S BROADEST LINE ASSURES YOU THE RIGHT PUMP FOR EVERY JOB

Types CG and CGL. Sizes ¾" to 10". Capacities to 5900 GPM; heads to 200 ft. Liquid ends of WORTHITE alloy.

Type CF. Sizes 1" to 4". Capacities to 1000 GPM; heads to 130 ft. Standard, all iron and all bronze.

Type CQ. Sizes 1½" to 3". Capacities to 600 GPM; heads to 130 ft. at 1750 RPM. Closed impeller. WORTHITE shaft and fittings.

Type L. Sizes 3" to 8". Capacities to 2250 GPM; heads to 200 ft. Single stage volute. For general service.

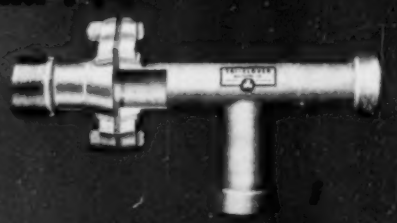
need help with your

CORROSION *problems?*

— let Tri-Clover SPECIALIZED EXPERIENCE lend a hand . . .

USE THE RIGHT FITTING TYPE FOR EVERY JOB . . .

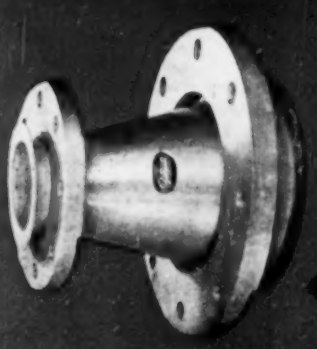
It will pay you to take advantage of Tri-Clover's 30 years of specialized experience in solving the most difficult corrosion problems. Having a *complete* line of stainless steel and nickel alloy fittings, valves and pumps to choose from, Tri-Clover engineers are able to recommend *exactly* the right type and size to meet your conveying line needs. If you prefer, send us a sample of your product for laboratory tests and we will furnish complete recommendations covering the type of corrosion-resistant fittings and lines best suited for your use. Illustrated are four typical Tri-Clover fitting types:



1 Assembled section of Flanged Conical-End Fitting showing IPS adapter. Available in a complete line, 1" thru 4" O.D.

2 World-famous Tri-Clover Sanitary Fittings and Valves are available in a complete line of stainless steel and nickel alloy types, 1" thru 4" O.D. for all sanitary code requirements.

3 Recessed-End Fittings . . . easily assembled by soldering, brazing or socket welding. Available in a complete line, ¾" thru 10" O.D.



4 Typical "Zephyrweld" Welding Fitting Reducer with Van Stone welding nipples and slip-on flanges for easy, fast assembly. Available in a complete fitting line, from ¾" thru 24" O.D.

See your nearest Tri-Clover Jobber or write for complete details.

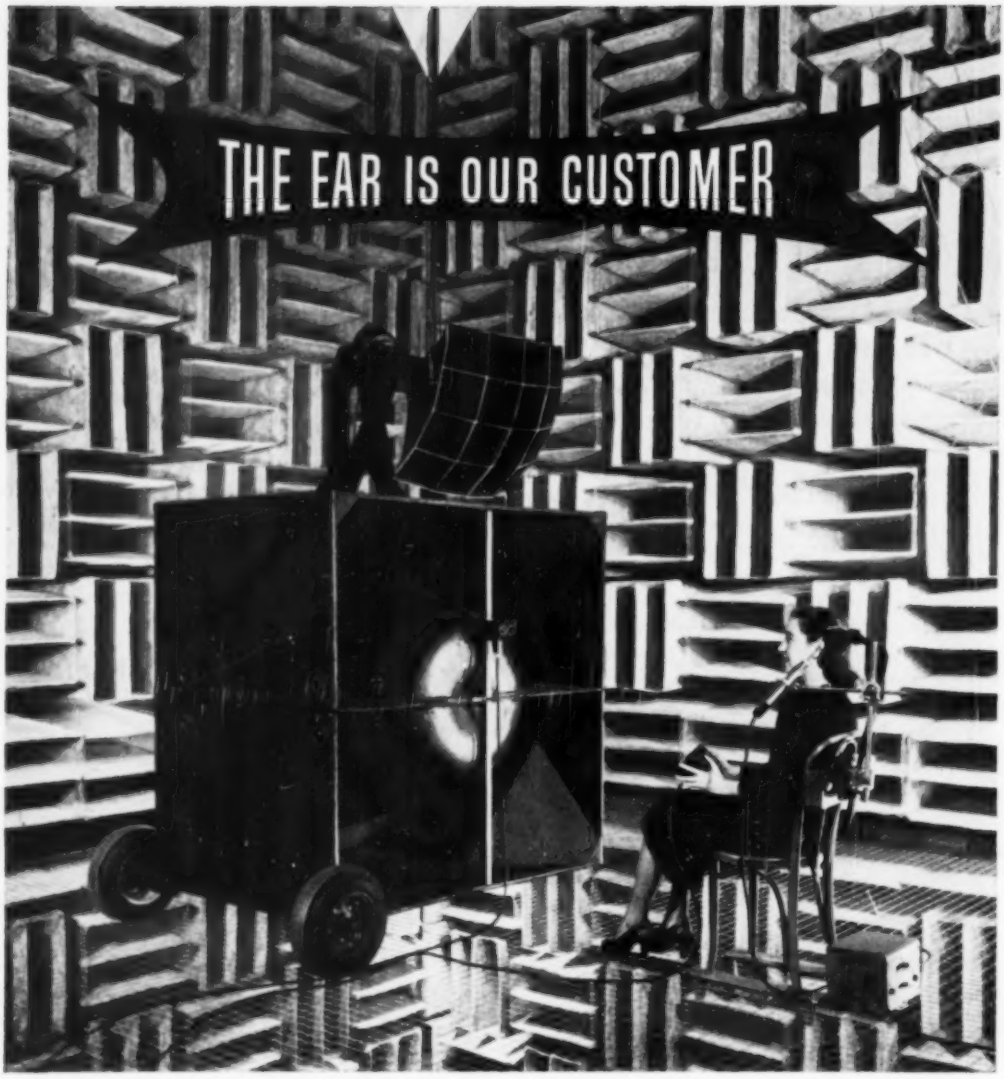
Tri-Clover MACHINE CO.

Kenosha, Wisconsin

TRIALLOY AND STAINLESS STEEL SANITARY FITTINGS, VALVES, PUMPS, TUBING, SPECIALTIES

FABRICATED STAINLESS STEEL INDUSTRIAL FITTINGS AND INDUSTRIAL PUMPS

THE Complete LINE



What happens when you hear? What happens *inside* your ear when sound waves come in from a telephone conversation?

Bell Telephone Laboratories scientists have developed special apparatus to help answer these questions, for the telephone system is designed to meet the ear's requirements for good listening.

In the test pictured above, the young lady sits before loudspeakers in a soundproofed room with a small hollow tube, reaching just inside the ear canal. Sounds differing slightly in frequency and intensity come from a loudspeaker. The subject seeks to tell one from another, recording her judgment electrically by pressing a switch.

Meanwhile, the same sound waves pass down the hollow tube to a condenser microphone, and a record is made of the exact sound intensities she identified. Results help reveal the sound levels you can hear clearly and without strain—the sounds your telephone must be designed to carry.

Scientists at Bell Telephone Laboratories make hundreds of tests in this manner. It's just one part of the work which goes on year after year at the Laboratories to help keep Bell System telephone service the finest on earth.

BELL TELEPHONE LABORATORIES

Exploring and inventing, devising and perfecting, for continued improvements and economies in telephone service.

FORMER WASTE PRODUCT MADE TO YIELD 7500 GALLONS OF ALCOHOL DAILY

..CAN I MAKE *Your* PROCESS CONTINUOUS?

"The sulphite used in converting wood pulp into paper formerly was discharged to waste, and the wood sugar in the pulp liquor was not utilized. Now sulphite liquor, once regarded as useless, yields ethanol, methanol and fusel oil. Two years after one plant started to process the sulphite liquor, 7500 gallons of ethyl alcohol were being produced daily.

"In the fermentation stage the yeast is separated from the beer by De Laval Yeast Separators, in which I — De Laval Centrifugal Force — make continuous separation possible."

Here is a good example of putting well known principles of production to a new use. Centrifugal force is usually able to speed up a separation process, and often, in doing so, improves the quality of the product.

Can De Laval Centrifugal Force be put to work for you?

● Ask for Bulletin 15-1.

THE DE LAVAL SEPARATOR COMPANY
165 Broadway, New York 6 427 Randolph St., Chicago 6
DE LAVAL PACIFIC CO., 61 Beale St., San Francisco 5
THE DE LAVAL COMPANY, Limited, Peterborough, Ont.

DE LAVAL *Processing Systems*

Easy to wear, effective *for the chemical*

M·S·A

Chemgard

APRONS AND SLEEVES

Tailored of easy-draping, translucent, flexible plastic, these modern protective garments combine correct fit with comfort and durability. Resistant to corrosive chemicals, harmful liquids, oil and grease, Chemgard Sleeves and Aprons feature electronically-welded seams throughout. Plastic neck and waist straps are bonded permanently to garment at one end, with adjustable fastener at opposite end. Non-absorptive, resistant to hardening, snagging and abrasion—odorless, easy to clean and keep clean! *Bulletin CZ-2.*

M-S-A SKULLGARD

Industry's most popular work hat for comfort with proved head protection. Light, sturdy, unaffected by common chemicals, water or grease—high dielectric strength—flexible sweatband and shock-absorbing inner head cradle for day-long wearing ease. *Bulletin DK-15.*

M-S-A FACESHIELDS

Wide-area face and neck safety against acid splashes, light flying particles, etc. Visor of clear vinyl plastic is quickly replaceable—molded fiber headgear is shaped to fit the head, with weight supported by center crown strap. Instant size adjustment. *Bulletin No. CH-3.*

M-S-A
RUBBER FRAME GOGGLES

Molded, genuine rubber goggles, with indirect ventilation holes—preventing worry of chemical fluids, dusts and foreign particles. Large, sharp-cushioned octagon lens, easily replaceable. Frame provides air-tight seal on face without binding. *Write for details.*

head-to-foot protection *industries worker—by* MSA

SAFETY EQUIPMENT HEADQUARTERS

M·S·A
Acid Hood

Covering head, shoulders, back and chest, safely protecting the wearer against acid splashes and sprays, the specialized M.S.A. Acid Hood combines lightweight comfort with unobstructed vision through a large, replaceable plastic lens.

Made of vinyl plastic, unaffected by acids, caustics, corrosive liquids, oil or grease, the Hood snap-fastens to pivoted shell and adjustable headgear of white coated vulcanized fiber. Baffled air vents at sides prevent entry of splashed liquids. *Write for Bulletin CF-24.*

M·S·A RUBBER GLOVES

Including rubber acid gloves, synthetic white rubber gauntlets, neoprene latex, synthetic coated fabric, and turn-cuff gloves. Sizes, lengths, weights as specified. *Write.*

M·S·A WHITE RUBBER BOOT

Shows acid splashes clearly. All-rubber, well-reinforced at wearing points for hard service. Tough, durable sole and heel are heavily corrugated to prevent slipping. *Bulletin CL-4.*

M·S·A WURKSHU

Water and acid proof—made of black synthetic rubber, over regular work-shoe last. Blucher upper, flexible sole, sponge cushion insole and steel Safety Toe. *Write.*

M·S·A FEND

A wide range of industrial skin creams, formulated for barrier protection against scores of specific skin irritants. *Bulletin FA-79.*

MINE SAFETY APPLIANCES COMPANY

BRADDOCK, THOMAS AND MEADE STREETS · PITTSBURGH 8, PA.

At Your Service:

54 BRANCH OFFICES IN THE UNITED STATES AND CANADA

A nickel-in-the-slot . . . or 1000 p.s.i. on the line

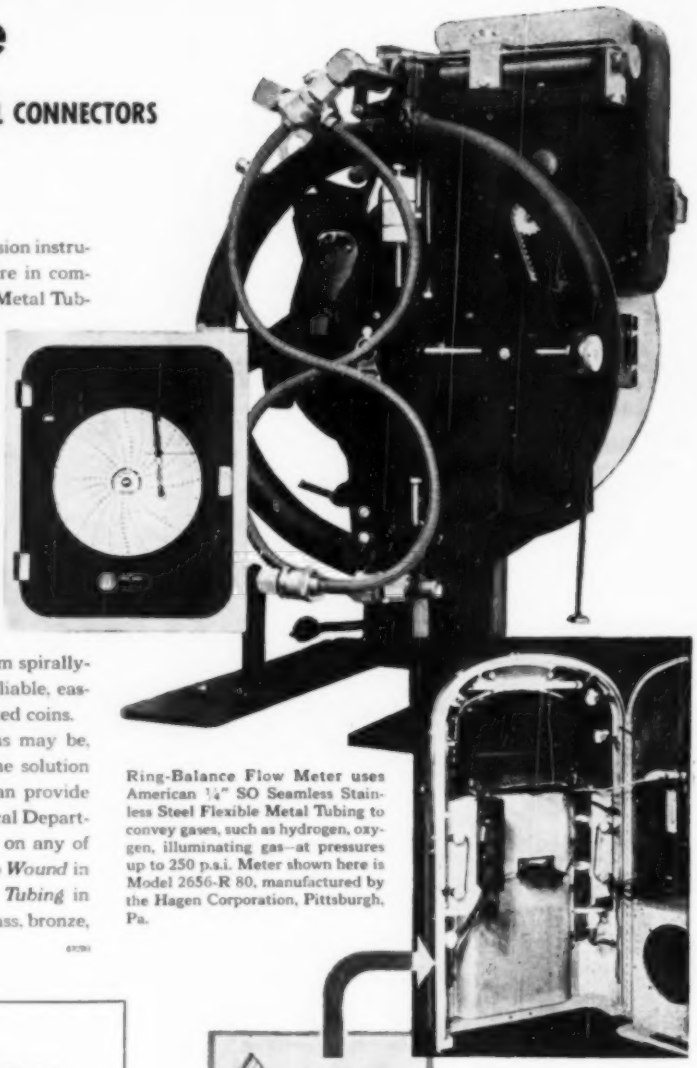
AMERICAN FLEXIBLE METAL CONNECTORS HANDLE BOTH PROBLEMS

These two radically different precision instruments have one noteworthy feature in common: both use American Flexible Metal Tubing, different types of course, but each "tailored" by us to do its job exactly right.

In the Hagan Ring-Balance Flow Meter two lengths of stainless steel seamless flexible metal tubing connect the meter with the gas lines. This rugged, precise connector is made from one-piece seamless tubing, corrugated for maximum flexibility.

In the Rock-Ola Coin-operated phonograph flexible metal hose, oval in cross-section and made from spirally-wound aluminum strip, forms a reliable, easily-installed return chute for rejected coins.

Interesting as these applications may be, you will be more satisfied with the solution American Flexible Metal Hose can provide for your own problem. Our Technical Department is available for consultation on any of our flexible metal hose types: *Strip Wound* in I.D.'s through 12" and *Seamless Tubing* in I.D.'s through 4"—both types in brass, bronze, stainless steel, nickel, etc.



Ring-Balance Flow Meter uses American ¼" SO Seamless Stainless Steel Flexible Metal Tubing to convey gases, such as hydrogen, oxygen, illuminating gas—at pressures up to 250 p.s.i. Meter shown here is Model 2656-R 80, manufactured by the Hagen Corporation, Pittsburgh, Pa.

Arrow points to American Oval UI Aluminum Flexible Hose as used for the coin rejector chute on coin-operated phonographs made by the Rock-Ola Manufacturing Co., Chicago, Ill. Construction of this hose is shown at left.

ANACONDA

American

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NEW... COMPACT Stainless Steel Gate Valve Combines Quality with Economy

COOPER ALLOY
Certified
UNION BONNET
SCREW END
GATE VALVE
FIG. 115
Union bonnet construction for long service life and simplified maintenance.
Minimum of six turns of packing assures effective sealing.
Ball and socket point contact discs adjust themselves in any position.
Back-seating for repacking under pressure.

At last, a compact, completely serviceable, stainless steel gate valve, especially designed by Cooper Alloy engineers to meet the demands of the process industries for an ECONOMICAL corrosion resistant valve that makes no compromise with quality.

Available in various stainless alloys, in sizes ½", ¾" and 1", this Cooper Alloy Certified valve is unusually well suited for fixed plant installations as well as for use on fabricated equipment.

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- Metal Goods Corporation
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- Mutual Mfg. & Supply Co.
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- Horace T. Potts Co.
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- Schnitzer Alloy Prod. Co.
- Shawinigan Chm. Ltd.
- Tay-Holbrook, Inc.
- Wiley Alloy Tube Company

Also Available From Leading Stainless Steel Jobbers

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FOR YOUR INFORMATION

Recently completed additional manufacturing facilities further increase Monsanto's production of phosphorus, phosphoric acid and phosphates.

The world's largest electrical furnaces work 'round the clock to refine Monsanto's elemental phosphorus of better than 99.9% purity.

SOURCE OF QUALITY
In Phosphoric Acid and Phosphates

Monsanto phosphoric acid and phosphates are derived from Monsanto-produced pure elemental phosphorus. From this pure phosphorus, quality-controlled Monsanto processes bring you phosphoric acid and phosphates with uniform, high quality. These products and some of their many uses are listed below. Information and prices will be sent promptly on request.

PHOSPHORIC ACID — Soft drinks, rustproofing compounds, metal cleaning, gelatin, jelly and preserves, textiles, sugar refining, pharmaceuticals, water treatment, electro-polishing.

SODIUM PHOSPHATES

Mono Sodium — Water treatment, textiles, acid cleaning compounds.

Di Sodium — Cheese, leather, textiles, detergents, water treatment, dye, pigments.

Tri Sodium — Water softener, detergent, metal cleaner, water treatment, textiles.

Tetra Sodium Pyro — Soap, detergents, cheese, textile dyeing, bleaching and finishing, metal cleaning, oil-drilling mud, water treatment, water softener, glass, degreasing.

Tri Poly — Soap, detergents, water softener, textile dyeing, bleaching and finishing, degreasing, metal cleaning, clay refining.

Acid Sodium Pyro — Baking powder, oil-drilling mud, electroplating.

CALCIUM PHOSPHATES

Mono Calcium — Baking powder, self-rising flour, prepared flour, mineral supplement.

Di Calcium — Tooth paste, tooth powder, mineral supplement, pharmaceutical.

Calcium Pyro — Mineral supplement, pharmaceutical.

Tri Calcium — Tooth paste, tooth powder, anti-caking agent, mineral supplement, pharmaceutical.

AMMONIUM PHOSPHATES

Mono Ammonium — Fireproofing, yeast, malt, plant nutrient.

Di Ammonium — Fireproofing, yeast, plant nutrient.

POTASSIUM PHOSPHATES

Mono Potassium — Pharmaceuticals.

Di Potassium — Fermentation, nutrient solutions, pharmaceuticals.

Tri Potassium — Oil refining.

Tetra Potassium — Soap, textiles, water softener.

FERRO PHOSPHATES
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IRON PHOSPHATES
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ALKYL ALKALI PHOSPHATES
SPECIAL PHOSPHATES

ENJOY the interesting story of phosphorus in "Phosphorus... The Light Bearer." Sent upon request.

'ANT FACILITIES LARGER SUPPLIES ICIZER 141

tile plasticizer aids ing, improves quality f vinyl products

Recently completed manufacturing facilities now assure greatly increased supplies of Santicizer* 141, Monsanto's versatile plasticizer for polyvinyl chloride and vinyl co-polymers. It is priced to compete with other primary vinyl plasticizers.

Santicizer 141's wide compatibility and strong solvent action make possible economical reductions in processing temperatures — permit broader choice of other compounding materials. It also contributes the following desirable properties to vinyl products: low-temperature flexibility, flame resistance, light stability, low volatility, resistance to embrittlement, low toxicity.

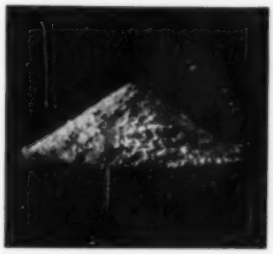
Detailed information on Santicizer 141 — and on other members of Monsanto's family of plasticizers and resins — will be sent promptly on request.

BOOKLET DESCRIBES MANY APPLICATIONS FOR PENTA

The industrial wood preservative

This booklet offers useful information on how Monsanto's PENTAchlorophenol can be used profitably to protect wood construction from decay and destructive insect attack.

Write for a copy of "Monsanto PENTAchlorophenol for Preserving Wood in Industrial Construction." Learn about this dependable, CLEAN, proved method of protecting your investments in wood.



BENTHAL

Improves quality of protective coatings at reasonable cost

Benthal* enables manufacturers of short oil modified resins to produce high-quality coatings economically. By replacing a portion of the dibasic acid with Benthal, a monobasic acid, it is possible to retard bodying, permit longer processing, thus reducing the acid value of alkyd resins.

Since Benthal becomes part of the resin molecule, it acts as an internal plasticizer — improves the flexibility and adhesion of dried films. Benthal is available for prompt shipment at reasonable cost . . . For more information on its processing advantages, send for a copy of Monsanto Technical Bulletin No. O-D-503, "Benthal Applications in Alkyd Resins."

BIOLITE

New product developed for mildew control in laundries

A new Monsanto product, Biolite, has proved highly successful as a mildew preventive. It is especially useful in laundries, and is being marketed through laundry supply houses.

Biolite is a formulation of Santobrite,* Monsanto's Sodium Pentachlorophenate, Technical. This is another new application for Santobrite, which is already used extensively for slime and algae control in industrial cooling water systems, microorganism control in pulp and paper manufacture, weed control.

AROCLOR 1248

Eliminates Fire Hazard In Die-Casting Systems

Monsanto's AROCLOR* 1248, nonflammable hydraulic fluid for metal die-casting machines, brings greater safety to the industry by eliminating the danger of fires. Economical? Of course! The cost of AROCLOR 1248 may be only half that of the fluid you now are using because of AROCLOR'S low price and low "make-up" requirement.

AROCLOR 1248 has given continuous, satisfactory service in individualized units for ten years . . . has delivered equal results in centralized systems for two years.

Look at these significant test results: AROCLOR 1248 has *no fire point*, spontaneous ignition temperature of 1,300° F. AROCLOR 1248 spray or mist requires 64% oxygen for combustion. These results establish the nonflammable and noncombustible qualities of AROCLOR 1248.

AROCLOR 1248 is noncorrosive and has such lubricating qualities that it usually is employed in die-casting systems without the addition of other lubricants. For complete details, ask for Monsanto Technical Bulletin No. P-137.

NEW TEXAS CITY STYRENE PLANT DEDICATED IN APRIL

In April, Monsanto dedicated its newly reconstructed Texas City, Texas, styrene plant.

Highlight of the dedication was a ceremony to honor the memory of 145 Monsanto employes who perished when the styrene plant was destroyed by the explosion of S.S. Grandcamp, a nitrate-laden steamer.

The new plant embodies many improvements over the old installation —is now in full-scale production.

MANY INTERMEDIATES NOW AVAILABLE FOR PROMPT SHIPMENT

Offer wide possibilities for product development and improvement

Of interest to the chemical process industries is the wide selection of Monsanto intermediates now available for immediate delivery.

Some of these chemicals may well serve as stepping stones to development of new products, or to improvement of processes presently used.

para-Aminobiphenyl • *para*-Nitrobiphenyl • *ortho*-Anisidine • *para*-Anisidine • Benzoic Acid, Technical • Benzyl Chloride • Dichloroaniline • *ortho*-Chloroaniline • *para*-Chloroaniline • *ortho*-Chlorophenol • *para*-Chlorophenol • Cyclohexylamine • Dicyclohexylamine • Dinitroaniline • Dinitrochlorobenzene, 46.5° and 48° • Monsanto Salt (*ortho*-Chlor *para*-Toluene Sodium Sulfonate) • *ortho*-Nitroaniline • *ortho*-Nitrochlorobenzene • *ortho*-Phenetidin • *para*-Phenetidin • Phenol, U.S.P. • Phenolsulfonic Acid, 65% and 70% • Sodium Benzoate, Technical • *para*-Toluenesulfonamide • *para*-Toluenesulfonchloride • Toluenesulfonic Acid

*Reg. U. S. Pat. Of.

☆ ☆ ☆

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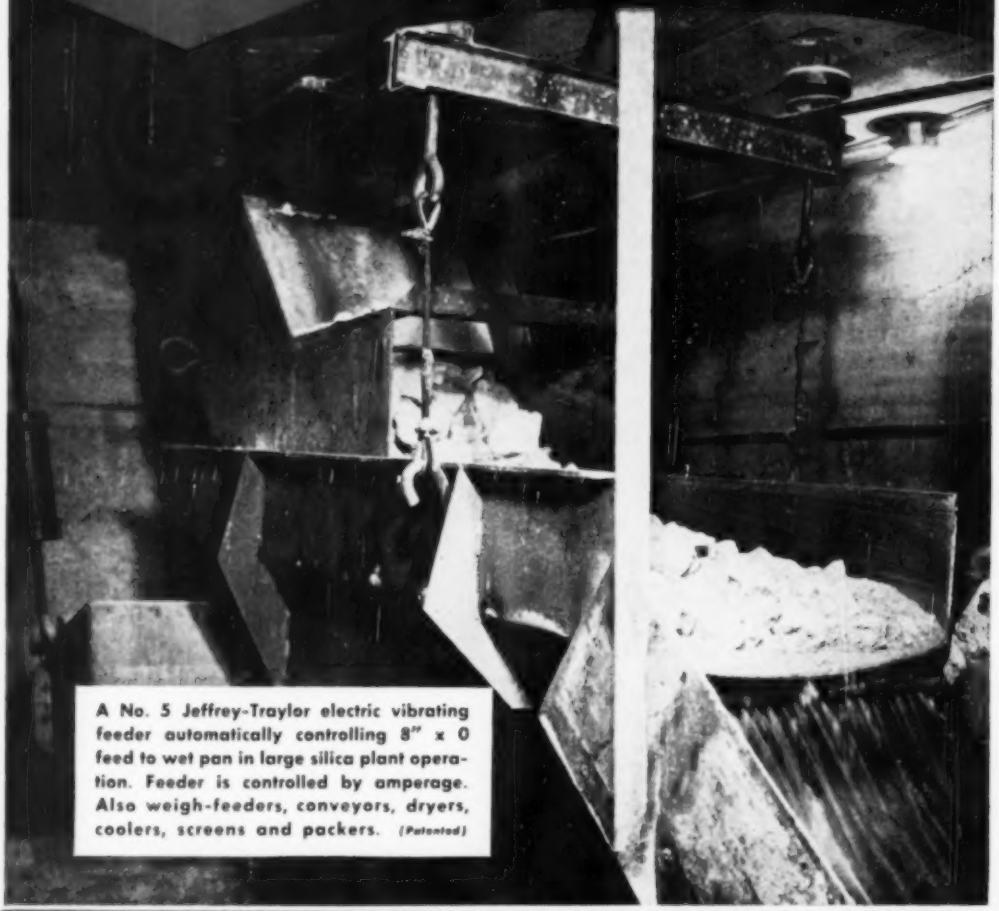

A No. 5 Jeffrey-Traylor electric vibrating feeder automatically controlling 8" x 0 feed to wet pan in large silica plant operation. Feeder is controlled by amperage. Also weigh-feeders, conveyors, dryers, coolers, screens and packers. *(Patented)*

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Complete Line of Material Handling, Processing and Mining Equipment

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U.S.I. CHEMICAL NEWS

May ★ A Monthly Series for Chemists and Executives of the Solvents and Chemical Consuming Industries ★ 1949

Progress Reported On Hydrocarbon Synthesis Plant Construction

Over 30% Completed Now, Plant Is to Begin Operations This Year

Construction of the Carthage Hydrocol, Inc. hydrocarbon synthesis plant at Brownsville, Texas, is rapidly progressing and is expected to reach a peak some time this summer, officials connected with the project announce. Co-products of the new synthesis plant — in excess of 300,000 pounds daily of water-soluble oxygenated compounds — are to be separated and refined by Stanolind Oil & Gas Company to yield commercial quantities of such important chemicals as methyl, ethyl, normal-propyl, normal-butyl, and normal-amyl alcohols; acetaldehyde, propionaldehyde, and butyraldehyde; acetone, methyl ethyl ketone, methyl propyl ketone, and methyl butyl ketone; and acetic, propionic, and butyric acids.

Important Chemicals Will Be Available

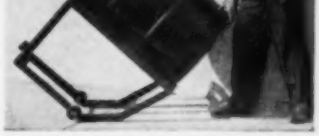
Participating in the project with Carthage Hydrocol, Inc., and Stanolind Oil & Gas Company, U. S. Industrial Chemicals, Inc., will distribute to industry or use all of the above water-soluble oxygenated co-products of the synthesis. Included in such use will be shipments of some of these synthesis chemicals by U.S.I. to certain of its other plants for producing still other compounds of extensive and diversified commercial interest.

The plant site selected has many advantages which will contribute to the success of this important pioneering development. Its location makes feasible the use of both rail and water transportation. Large quantities of sea water are available for process and utility requirements. A concentration of natural gas supplies within a 50-mile radius insures raw materials for years to come.

Over thirty per cent of the synthesis plant proper has been completed and an accelerating construction program points to initial operation late this year.

New Type of Drum Truck

A new type of drum truck is designed to make it easy for one person to handle a full drum. The truck is unique, it is claimed, in that it has three points of leverage, making it possible for a drum to be swung on each point of leverage in turn.



Pyrenone-Based Dairy Sprays Offer Safe Control of Insects

Pyrenone-Treated Cows Are Free of Stable Flies, Horse Flies, Deer Flies, Horn Flies — Give Contamination-Free Milk

Dairy cattle sprays that control stable flies, deer flies, horse flies, and horn flies — yet are non-toxic to humans and warm-blooded animals — can be formulated now, using Pyrenones as the active ingredient. The fact that no contaminants are carried over into the animals' milk from treatment with pyrenone-based sprays is good news to dairymen.

The United States Department of Agriculture reports that piperonyl butoxide increases the killing action and lasting effect of pyrethrum against horn flies, stable flies, tabanids, and lice on cattle; and such combinations have been declared unobjectionable by the Food and Drug Administration.

No contaminants are carried over into the milk of cows treated with Pyrenones. These combinations of piperonyl butoxide and pyrethrum give effective control of a wide range of insects attacking dairy cattle, yet leave no residues toxic to humans or warm-blooded animals.

Emulsions Based on Pyrenones Are Safe, Highly Effective

Almost three years of testing has shown the highly specific action of pyrenone emulsions against flies. Field tests that were conducted included treatment of herds in the Northeast, the South, the semi-arid Southwest, and different portions of the Great Plains States.

In practical tests pyrenone emulsions gave protection against horn flies for 14 days

MORE

'Heat Radiation Pictures' Are Made with Phosphors

Heat and heat distribution of objects can be recorded now over a wide range of temperatures, it is reported, by two new techniques making use of sensitive phosphor compounds. In one of the new methods, scientists point out, a screen is coated with specially prepared phosphors, and a curved, metal mirror is used to focus the heat radiation of an object on the screen. Here, it is claimed, the image can be examined under ultraviolet light or can be photographed. Reports indicate that since all radiation produces a little heat, it is theoretically possible to record many things with refinements of the heat radiation technique.

Heat Distribution Is Recorded

In a related technique, phosphors are said to be coated directly on an object to get a picture of its heat distribution, which can be recorded in still or motion pictures. Unusual sensitivity is obtained in thermography, scientists state, pointing out that certain phosphors show a 20 per cent change in brightness with each Centigrade degree of change in temperature. Thermography can be used over temperatures ranging from that of liquid air to four or five hundred degrees Centigrade, it is claimed.

New-Type Air Filter Uses 'Curled Casein Filament'

Commercial production of "curled casein filament" for use in a new-type air filter for automobiles has followed the discovery of an improved process for spinning fiber from casein, it is announced. The new filter, intended to supersede oil-bath air cleaners now used on many cars, is said to have a chemically treated air-cleaning element made of 80 per cent casein filament and 20 per cent wool. When the filter element becomes clogged, the filament-containing cartridge can be discarded, it is claimed, and a clean one inserted, thus eliminating the need for washing the filter.

The new milk-protein fiber, described as highly resilient, dustless, and odorless, may be colored as desired and has promise for use in many other types of product.

Methionine Has Sparing Action on Pantothenic Acid Requirements

Study of the sparing action of proteins on the pantothenic acid requirements of rats has recently revealed that methionine is one of the amino acids responsible for such activity. This work was recently reported at the west coast meeting of the American Chemical Society. The marked sparing action of methionine improved both growth and survival of the deficient animals.

ADVERTISEMENT—*This entire page is a paid advertisement* *Printed in U. S. A.*

May ★ **U.S.I. CHEMICAL NEWS** ★ 1949

New Colorimetric Test To Determine Barbiturates

A newly devised colorimetric method for determining barbiturates is said to require fewer extractions than tests currently employed. The new determination reportedly depends on the formation of a stable color complex by the reaction of the barbiturates with a cobalt salt in an anhydrous medium.

Authors of the new method mention that the usual gravimetric method of determining barbiturates is subject to considerable error. Foreign materials as well as the drug may be extracted by the solvents and weighed along with the active materials, it is said. Also, under the older methods, repeated extractions are needed to free the drug from the carrier, the scientists state.

CONTINUED

Pyrenone Dairy Sprays

during dry weather and for eight days during rainy weather. Sprays applied only to the bellies of animals gave a high degree of control of horn flies. Reports from nine different states show protection from stable flies and different species of large horse flies for a period of two to seven days.

Pyrenone sprays have been successfully used in treating barn surfaces against house flies and resting stable flies, as well as against cluster flies that rested on the treated surface.

Other Insects Are Also Controlled

Because pyrenones leave no toxic residues harmful to humans or warm-blooded animals, and because they are so versatile in their insecticidal action, they can be used effectively on sacks of feed and on walls and floors for killing grain moths and beetles. And pyrenone-based formulations safely control such common insects as ticks, cattle lice, fleas, mites, bedbugs, ants, spiders, cockroaches, and other pests about the dairy, farm or ranch building.

'Portable Sound Traps' Control Unwanted Noise

New-type functional sound absorbers, claimed to have greater efficiency than many of the acoustic wall surfaces developed in the last two decades, have been studied experimentally. The new portable sound traps are said to be made up of a combination of wood and binder applied on a pair of hollow cones which are fastened together base to base. Described as one step forward in the direction of increased control over aimless noise, the new devices hold promise, by virtue of their versatility, of solving acoustical problems in many rooms used for different purposes at different times.

New Device Distinguishes Over 100,000,000 Colors

An automatic machine, so precise it can distinguish more than 100,000,000 colors, and capable of integrating continuously over all portions of the visible spectrum, has been developed recently, it is reported. The machine is said to tell immediately whether a given color will match another color and, if not, will describe the difference between them. The device reportedly is a combination of an electronically controlled ball and disc mechanism and a spectrophotometer. Together the two instruments can measure and analyze color in 2½ minutes, and can yield a numerical specification of what we see with hitherto unobtainable accuracy, it is claimed.

Glass Fibers Now Dyed

Glass fibers having no affinity as such for dyestuffs can now be dyed, it is claimed, using a recently patented process. The fibers are treated, according to the patent, with the unhardened soluble products of the reaction between formaldehyde and a complex organic compound. While the unhardened character of these products is maintained, the material is treated with a water-soluble organic dyestuff containing at least one sulfonic acid group, the patent states.

TECHNICAL DEVELOPMENTS

Further information regarding the manufacturers of these items may be obtained by writing U.S.I.

Concrete floors that simulate tile in appearance and durability are said to be produced by adding a new dry powder of high coloring power directly to the topping when laying concrete. **(No. 447)**

A new treated fabric for patching metal or wood, said to repair rusted-out portions of auto panels, tin roofs, wash tubs, etc., is expected to find wide use in minor household and farm repairs. **(No. 448)**

Fishermen need not dig for worms, it is claimed, if they use a mixture now on the market. Sprinkled over the ground, the "worm bait" is said to bring worms to the surface in 2 or 3 minutes. **(No. 449)**

A new floor enamel for brush or spray application is described as waterproof, adhesive to wood, metal, and concrete, fast-drying, and exceptionally wear-resistant. It is said to be impervious to grease, oils, brine, alcohols, petroleum solvents, soaps, and most acids. **(No. 450)**

A new durable water repellent for wool and wool-blend fabrics also makes fabrics resistant to non-oily spots and stains, and adds crease- and wear-resistance, the makers state. **(No. 451)**

For use in flame-proofing, wood treating, etc., a high-melting organic, said to have the highest melting point known for a simple organic compound, is reported to be now in semi-commercial production. **(No. 452)**

Laminating acetate or vinyl films to all kinds of plastic sheeting is reported possible now using a new process. **(No. 453)**

A new acoustical tile is claimed to have high sound-absorbing properties and to be light in weight and non-combustible. It has excellent thermal insulation value, is unaffected by humidity, and will not warp, buckle, expand or contract, the manufacturers assert. **(No. 454)**

A sealer, undercoat, and flat finish are said to be provided by one application of a new oil-based paint that can be used, the makers state, over plaster, wall board, brick, cement, concrete, wood, metal, or wall paper. **(No. 455)**

Wrinkle-resistant cotton cloth that is also shrink-proof is reported produced by treating with a modified resin, said not to affect the fabric's strength. Treated fabric shows little wrinkling after three days wear, and is resistant to dust, soot, and soiling, the makers state. **(No. 456)**

To protect sides and bottoms of beakers against mechanical shock and to prevent direct contact of hot beakers with a table top, a beaker holder which accommodates 1000, 1500, and 2000 ml. beakers is reported available. **(No. 457)**

U.S.I INDUSTRIAL CHEMICALS, INC.

60 EAST 42ND ST., NEW YORK 17, N. Y. U.S.I. BRANCHES IN ALL PRINCIPAL CITIES

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Amyl Alcohol
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Specially Denatured—all regular and anhydrous formulas
Completely Denatured—all regular and anhydrous formulas
Pure—190 proof, C.P. 96%
Absolute
*Super Pyro Anti-freeze
*Solox proprietary Solvent

***ANSOLS**
Ansol M
Ansol PR

ACETIC ESTERS
Amyl Acetate
Butyl Acetate
Ethyl Acetate

OXALIC ESTERS
Dibutyl Oxalate
Diethyl Oxalate

PHTHALIC ESTERS
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Dibutyl Phthalate
Diethyl Phthalate

OTHER ESTERS
*Diatol
Diethyl Carbonate
Ethyl Chloroformate

INTERMEDIATES
Acetoacetanilide
Acetoacet-ortho-anisidide
Acetoacet-ortho-chloroanilide
Acetoacet-ortho-toluidide
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Ethyl Acetoacetate
Ethyl Benzoylacetate
Ethyl Sodiumoxalacetate

ETHERS
Ethyl Ether
Ethyl Ether Absolute—A.C.S.

FEED CONCENTRATES
Riboflavin Concentrates *Vacotane 40
*Curbay B-G *Special Liquid Curbay

ACETONE
Chemically Pure

RESINS (Synthetic and Natural)
*Araplaz—alkyds and allied materials
*Arofene—pure phenolics
*Arochem—modified types
Ester Gums—all types
Congo Gums—raw, fused & esterified
Natural Resins—all standard grades

INSECTICIDE MATERIALS
*Pyrenone Concentrates
Pyrethrum Products
Rotenone Products

INSECTIFUGE MATERIALS
*Indalone
*Dimelone
Triple-M-ix Repellents

OTHER PRODUCTS
Collodions Urethan, U.S.P.
Nitrocellulose Solutions dl-Methionine
Ethylene

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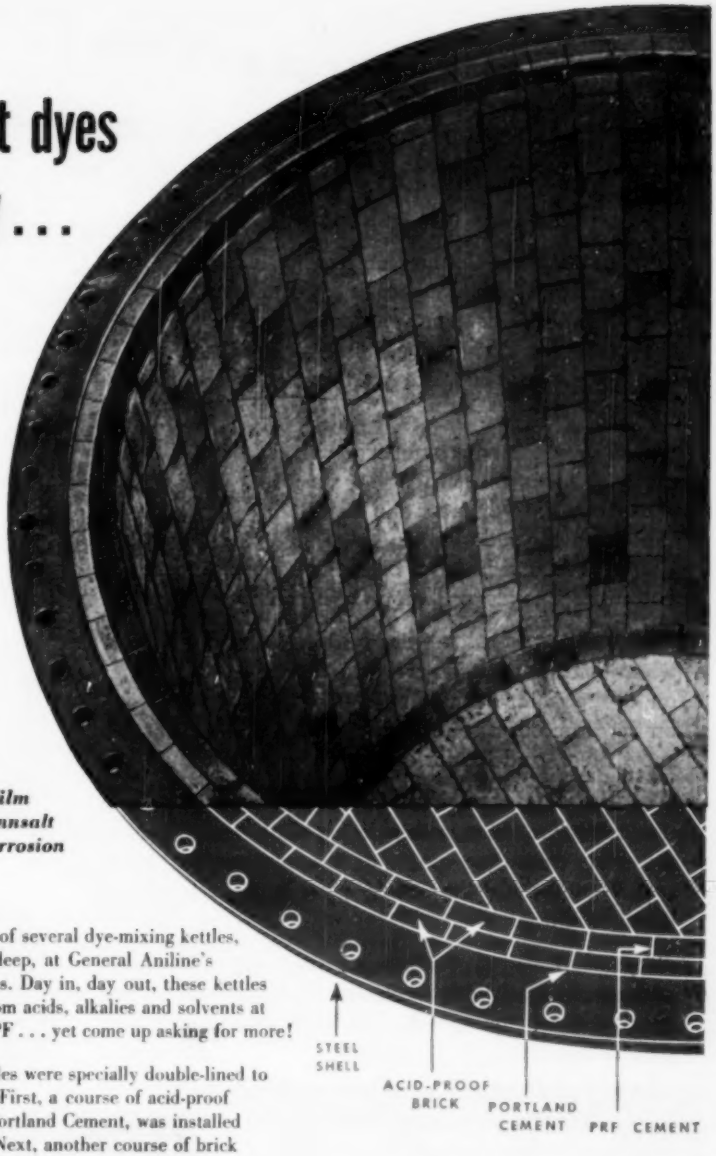
The kettle that dyes every day . . .

but lives longer on a diet of

H_2SO_4
HCL
Alkalies
Benzol
Toluol
Xylol
Acetone



General Aniline & Film Corporation uses Pennsalt Cements to resist corrosion

You're gazing into one of several dye-mixing kettles, 8′ in diameter by 15′ deep, at General Aniline's Rensselaer, N. Y., works. Day in, day out, these kettles really take a beating from acids, alkalies and solvents at temperatures up to 300°F . . . yet come up asking for more!

That's because the kettles were specially double-lined to resist corrosive agents. First, a course of acid-proof brick, laid entirely in Portland Cement, was installed against the steel shell. Next, another course of brick . . . laid up in Pennsalt PRF Cement.

Because of its superior resistance to acids, alkalies and solvents, Pennsalt PRF Cement is doing an efficient job of protecting the kettles, assuring long trouble-free service. Pennsalt Cements are easy to work with, and give good protection with minimum thickness. If you have a corrosion problem, Pennsalt's technical field men and engineers will gladly study it with you. Write to Special Chemicals Division, ***Pennsylvania Salt Manufacturing Company,*** Philadelphia 7, Pa.

PENNSALT

Corrosion-Resistant Cements of many types for Acids, Alkalies, Solvents

For Motor Protection That Keeps Machines Running

Use 1 of These 4 Century Motor Types

The four types of Century motors shown here are designed to resist the dangers of hazardous atmospheres as described below. As a result they keep machines operating, keep shutdowns to a minimum.

Form J—open rated, general purpose motor—meets the needs for most installations where operating conditions are relatively clean and dry. The top half of the motor frame is closed to keep out falling solids or dripping liquids.

Splash Proof motor—gives the necessary protection where plants must be washed down—keeps water out of the motor even when a hose is applied directly on the frame. It also provides protection against rain, snow, sleet, and ice for outdoor installations.

Totally Enclosed Fan Cooled motors—protect against grain dusts, mist, or fog that would destroy the vital operating parts of the motor. The inner frame protecting the motor is sealed to keep out harmful matter.

Explosion Proof motors—protect against atmospheres charged with explosive dusts or gases. See specifications for specific kinds of explosive hazards.

Century builds a complete line of electric motors in sizes from 1/6 to 400 horsepower to meet the requirements of industrial and commercial needs.

Specify Century motors for all your electric power requirements.

Popular types and standard ratings are generally available from factory and branch office stocks.

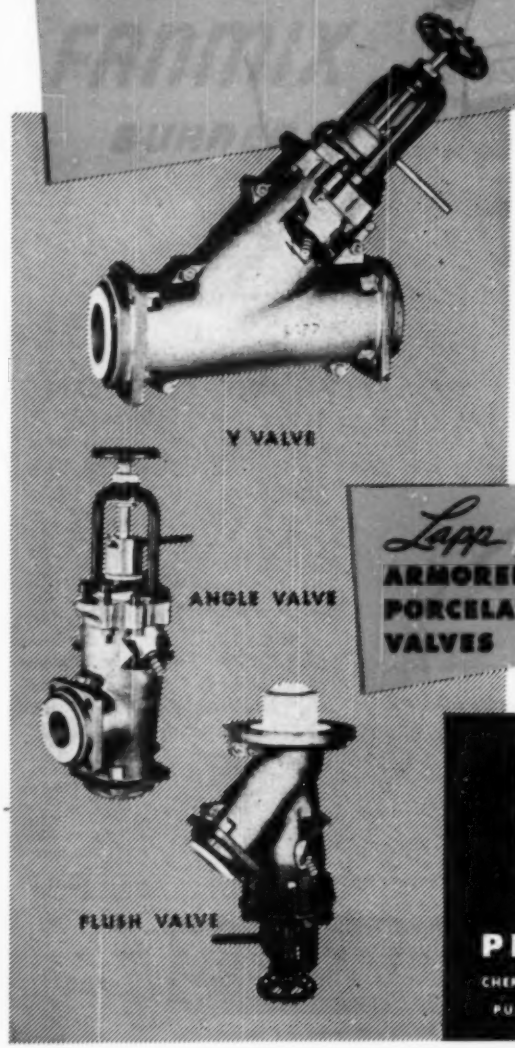
Century C MOTORS

CENTURY ELECTRIC COMPANY
1806 Pine Street · St. Louis, 3 Mo.

Porcelain.. Armored..

For PURITY and CORROSION RESISTANCE

For OPERATING SECURITY



Lapp ARMORED PORCELAIN VALVES

● *Laboratory purity in industrial production* and *resistance to all acids except HF* are the chemical properties of processing equipment of Lapp Chemical Porcelain. Now the original Lapp Porcelain Valve is available completely encased in heat-treated acid-resisting silicon aluminum armor for protection against carelessness or accident. At a fraction of the cost of expensive alloy or lined valves, Lapp armored valves give maximum operating security as well as the purity and corrosion resistance of *solid porcelain*. Armored Y-valves in 1″, 1½″, 2″, 3″, 4″ and 6″ sizes; armored angle valves in 1″ and 2″ sizes; armored flush valves in 1½″, 2″ and 3″ sizes. Write for descriptive literature and specifications. Lapp Insulator Co., Inc., Process Equipment Division, 103 Maple St., LeRoy, N. Y.

Lapp

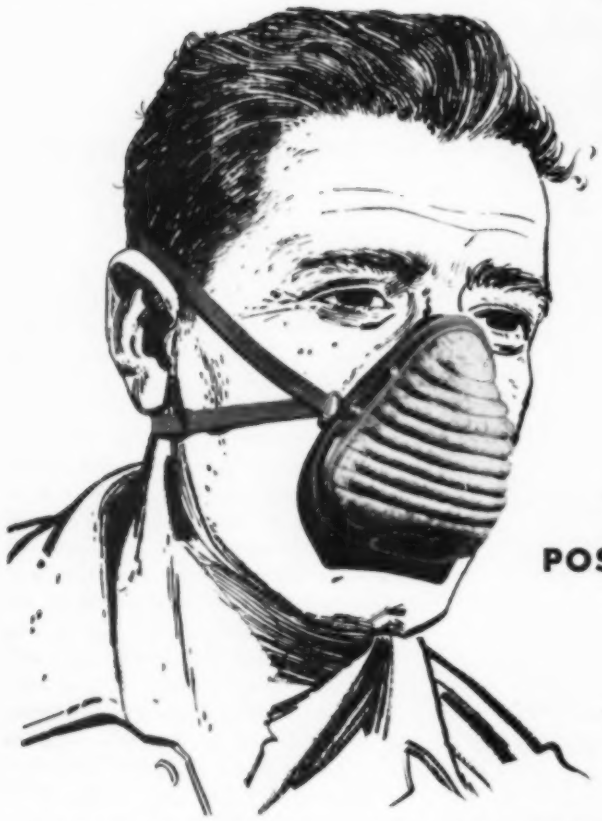
PROCESS EQUIPMENT

CHEMICAL PORCELAIN VALVES • PIPE • RASCHIG RINGS

PULSAFEEDER CHEMICAL PROPORTIONING PUMPS

Approved by the U. S. Bureau of Mines
#B.M. 2137 and #B.M. 2144

AO R-9100 and R-9100T Respirators



FOR LOW COST POSITIVE PROTECTION

Here is a respirator which does the protective job it is designed to do and is attractively priced. Its simple construction features a smooth, rubber face contacting mask plus a corrugated permanent type felt filter, reinforced by a wire frame.

Breathing is never labored, the non-reversing low-resistance exhalation valve will not stick—is out of the way and easily replaceable. The light weight (1¼ oz.) of the R-9100 appeals to workers, as does the unobstructed vision this respirator provides. Closely face-fitting, it may be worn under the helmet or with goggles. Cleaning is simple and easy—a quick shake, a slap of the hand or a light blast from an air hose does the job. Order from your nearest AO Safety Products Representative.

*** R-9100 Safeguards Against These and Similar Pneumoconiosis-Producing and Nuisance Dusts:**

Borax	•	Gypsum
Carbon	•	Coke
Glass	•	Charcoal
Grain	•	Wood
Graphite	•	Pollen
Cement	•	Flour
Limestone	•	Aluminum

**Specify the R-9100T for protection against Toxic Dusts such as Lead, Cadmium, Manganese, Selenium, Vanadium and their compounds.*

American Optical Company
SAFETY PRODUCTS DIVISION

Southbridge, Massachusetts • Branches in Principal Cities

You get MORE CAPACITY with a FANMIX BURNER

Increase Boiler Ratings On Present Or Planned Equipment

In all types of Coppus-Dennis FANMIX Burners — straight gas or combination gas-oil — we utilize the energy of the fuel under pressure to drive the burner fan and deliver air in the proper proportion to the fuel flow. This exclusive "pinwheel action" *mechanically* mixes fuel and air in exactly the right proportions for truly radiant, non-luminous heat.

The result is uniform temperature everywhere in the combustion chamber — no drifting "hot spots" — and complete combustion under all conditions. That's why you can release more heat into your present furnace — why in new installations you get more heat into smaller furnace space.

FANMIX Saves On Both Old and New Installations

FANMIX can easily be operated with your present furnace and stack, requiring only minor changes in other equipment. Or if you're planning on new boilers, remember that FANMIX relieves the furnace from the burden of mixing, creates its own forced draft and takes smaller pipe sizes. Which means you can plan on reduced combustion space, less stack, no forced draft equipment and lower installation costs all around.

Get the Whole Story

Coppus engineers FANMIX Burners to meet individual requirements, providing complete control over heat pattern and combustion . . . Learn more about how "pinwheel action" can step up *your* boiler performance to peak efficiency and economy — as it is doing throughout industry. Send for Bulletin 410-6. Coppus Engineering Corp., Worcester 2, Mass. Sales Offices in THOMAS' REGISTER. Other Coppus "Blue Ribbon" Products in BEST'S SAFETY DIRECTORY, CHEMICAL ENGINEERING CATALOG, REFINERY CATALOG, and MINING CATALOGS.

COPPUS ENGINEERING CORP.
225 Park Ave.
Worcester 2, Mass.
Please send Bulletin 410-6 to:
Name .....
Company .....
Address .....
City ..... Zone ..... State .....

How do your high temperature tubes stack up for LIFE/COST ratio?

PERHAPS your tubes are doing their job, but are they doing it at the lowest possible cost? It will pay you to look into these twelve Timken® high temperature steels . . . "tailored" to fit your requirements. They are specially developed to cope with specific problems of heat, pressure, corrosion, and oxidation. And *one* of them offers you the best life/cost ratio for your job.

Timken metallurgists, backed by 19 years of experience and research in high temperature applications, are qualified to recommend the one steel that will give you the service life you need at the lowest possible cost. The Timken Technical Staff, recognized authorities in the field, will be glad to help you with your high temperature tube problems.

Whichever analysis is selected, you can be assured of uniform high quality steel from shipment to shipment. The Timken Company insures this uniformity through complete and careful quality control from melt shop through final inspection.

Call on the Timken Technical Staff now for help in choosing the most efficient high temperature tube with the best life/cost ratio for you. There's no obligation. Write today to The Timken Roller Bearing Company, Steel and Tube Division, Canton 6, Ohio. Cable address: "TIMROSCO".

TIMKEN 18-8 STEEL TUBING Shows the best combination of creep strength, oil corrosion resistance and oxidation resistance up to 1500°F.

TIMKEN SICROMO 9 M STEEL TUBING This steel possesses the maximum corrosion resistance of any of the steels below the stainless group.

TIMKEN SICROMO 7 STEEL TUBING For applications requiring better corrosion resistance than can be obtained with 5% Chromium, 1750 steels.

TIMKEN SICROMO 5 S STEEL TUBING For oxidation resistance to 1500°F. Good creep strength and corrosion resistance to 1300°F.

TIMKEN 4-6% CR MO STEEL TUBING For service up to 1200°F. Superior corrosion resistance. Less oxidation resistance than Sicromo 3.

TIMKEN SICROMO 3 STEEL TUBING For service up to 1200°F. Has excellent oxidation resistance and good corrosion resistance.

TIMKEN 2¼% CR-1.0% MO STEEL TUBING For service up to 1150°F. Has greater resistance to creep than 2% Cr. ½% Mo. Steel.

TIMKEN SICROMO 2 STEEL TUBING For service up to 1200°F. where better scale resistance is required than can be obtained with 2% Cr. ½% Mo. Steel.

TIMKEN 2% CR ½% MO STEEL TUBING For service up to 1150°F. Intermediate corrosion resistance plus good creep strength, fair oxidation resistance.

TIMKEN DM STEEL TUBING For service up to 1150°F. This steel offers outstanding creep strength.

TIMKEN CARBON-MO STEEL TUBING For temperatures up to 1000°F. Improved creep strength makes it safer than carbon steel.

TIMKEN CARBON STEEL TUBING Generally for service not exceeding 900°F., where corrosion and oxidation resistance are not important.

TIMKEN

Fine Alloy

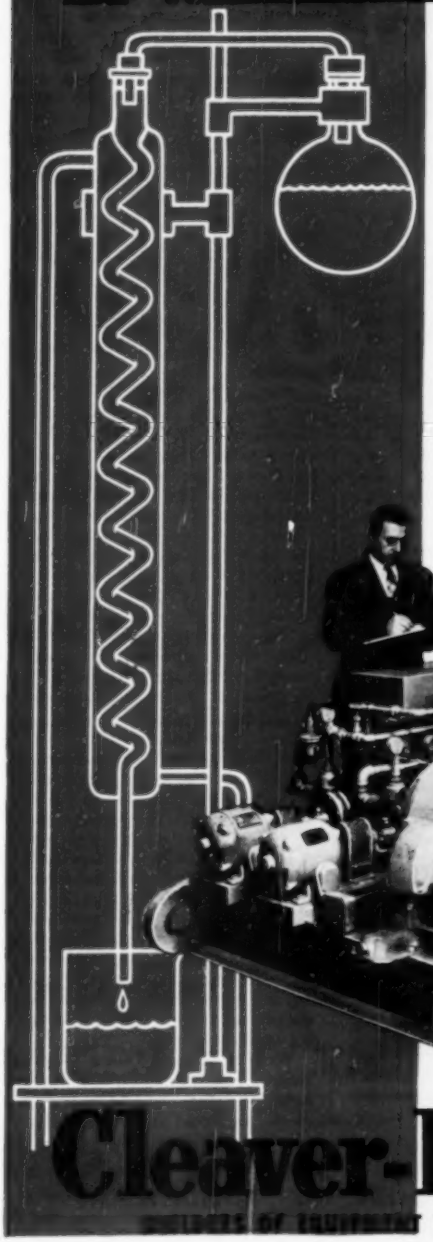
STEEL

and Seamless Tubes

YEARS AHEAD—THROUGH EXPERIENCE AND RESEARCH

Specialists in alloy steel—including hot rolled and cold finished alloy steel bars—a complete range of stainless, graphitic and standard tool analyses—and alloy and stainless seamless steel tubing.

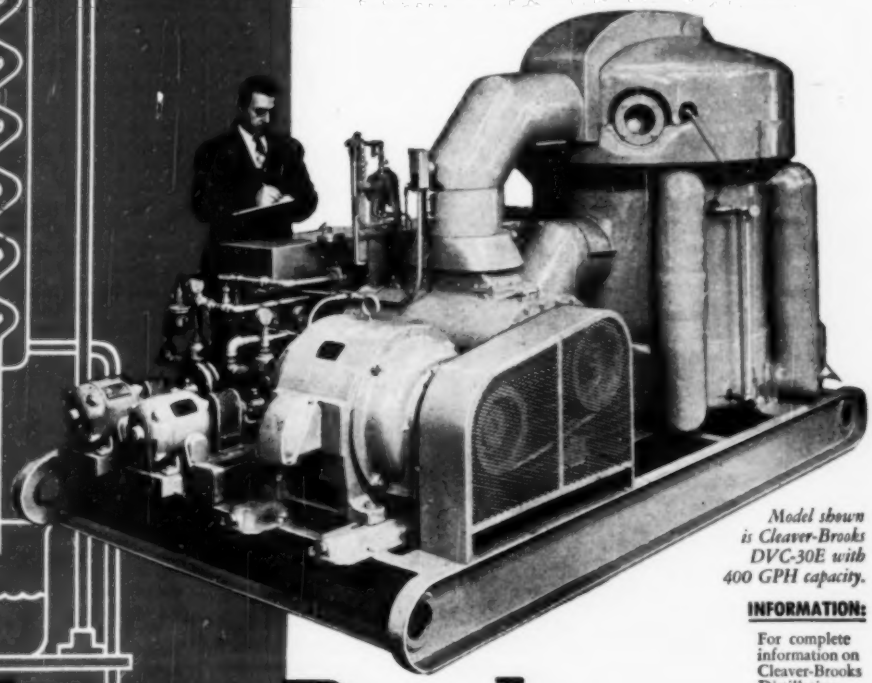
NEED PURE DISTILLED WATER -IN QUANTITY- AT LOW COST?



Pure distilled water with power consumption as low as 65 KWH per 1000 gallons.

CLEAVER-BROOKS Compression Distillation Units give you volume quantities of chemically pure (pyrogen free) distilled water suitable for intravenous or medical preparations, pharmaceuticals or chemicals. There's a model to fit your need — standard sizes 75 to 2100 gallons per hour. Larger sizes to fit your specific applications. Fully automatic in operation. Factory tested. Shipped as complete distilling plants in the smaller sizes and ready for field erection in larger plants.

CLEAVER-BROOKS COMPANY
339 East Keefe Avenue, Milwaukee 12, Wisconsin.



Model shown is Cleaver-Brooks DVC-30E with 400 GPH capacity.

INFORMATION:

For complete information on Cleaver-Brooks Distillation Units, write on your letterhead to Dept. CDU.

Cleaver-Brooks

BUILDERS OF EQUIPMENT FOR GENERATION AND UTILIZATION OF HEAT

COPPER ALLOY BULLETIN

MARINE AND POWER EDITION

REPORTING NEWS AND TECHNICAL DEVELOPMENTS OF COPPER AND COPPER-BASE ALLOYS

Prepared by Bridgeport Brass Company "Bridgeport" *Headquarters for* BRASS, BRONZE, *and* COPPER

Duplex Tubing for Lower Maintenance in Ammonia Refrigeration Systems

The rapid growth and penetration of mechanical refrigeration into industrial, commercial and domestic fields has introduced new corrosion and maintenance problems to operating engineers.

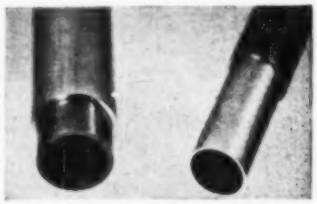
The selection of piping and tubing used in refrigeration and air conditioning requires careful consideration. In Freon refrigeration systems, copper tubing with brazed fittings gives satisfactory service since the copper resists corrosion from both Freon and water. Copper, however, is not satisfactory for direct contact with ammonia since it is attacked by the refrigerant.

The good corrosion resistance of steels to ammonia, both gaseous and liquid, explains the wide use of ferrous materials in the construction of equipment handling ammonia. However, steel tubes and pipes are subject to corrosion when immersed in brine, sea water or fresh water. This shortcoming can easily be overcome through the use of Duplex Tubing, consisting of non-rusting copper or copper-base alloy to the water side and steel to the ammonia side. This combination of Duplex Tubing is finding wide application not only for ammonia refrigeration, but, also, for equipment producing ammonia and its compounds.

The most popular combinations are low carbon steel combined with Copper, Admiralty or Red Brass for handling fresh water from rivers, lakes, ponds, and wells. Where sea water is used for cooling purposes, 80-20 Cupro Nickel, 70-30 Cupro Nickel, Duronze* IV (Arsenical Aluminum Bronze), Aluminum Brass, and Admiralty are preferred to copper because of their greater corrosion resistance to sea water. When the velocity of the sea water is comparatively high, Cupro Nickel, Duronze IV and Aluminum Brass are preferred because of their resistance to impingement corrosion.

Satisfactory Heat Transfer

Duplex Tubing is made by drawing together two tubes, one within the other. The close mechanical bond obtained in this manner results in very satisfactory heat transfer characteristics. Duplex composed of steel and copper has somewhat higher heat transfer properties than single walled steel tubing of the same size and wall thickness. The practical significance of this is that the designer can use the lower fouling factor for copper or copper-base alloys rather than the higher value customarily used for steel which rapidly develops an insulating coat of rust. This means that Duplex Tubes in smaller sized heat exchangers can sometimes replace larger units equipped with single-walled steel tubes. When units are retubed with Duplex Tubes of steel to copper or steel to copper-base alloys, greatly improved heat transfer properties may be anticipated, especially where excessive rusting (by water) is encountered on steel.

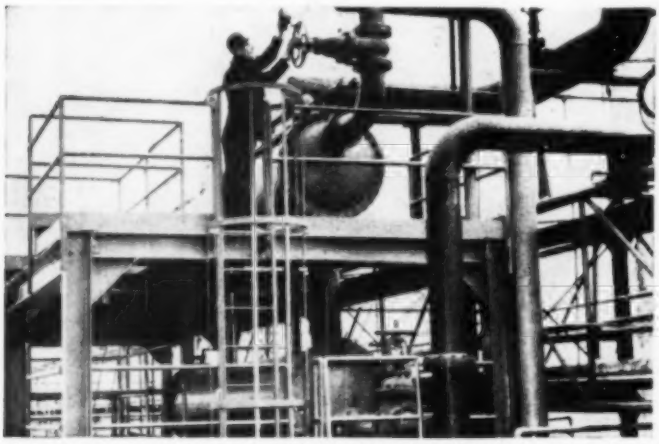


Duplex Tubing with outside tubes cut back to show construction.

Duplex Tubing Reduces Maintenance and Replacement

Remarkable savings in maintenance and replacement have been reported by users of Duplex Tubing for ammonia refrigeration systems. A small dairy which installed copper lined steel Duplex Tubing 11 years ago reported that previous to the replacement, rust and scale had to be removed from the inside of the steel tubes every three months and the tubes themselves were replaced about every three years. Since the installation of Duplex Tubing, no cleaning has been necessary and the original Duplex Tubing is still giving excellent service.

Write for "Duplex Tubing Technical Bulletin No. 746" and contact nearest Bridgeport office. *U. S. Pat. No. 2,093,380



Duplex Tubing of copper to the water side with steel to the ammonia side used in ammonia condensers. Courtesy Dow Chemical Company.

BRIDGEPORT BRASS

BRIDGEPORT BRASS COMPANY, BRIDGEPORT 2, CONN. • ESTABLISHED 1865

Mills at Bridgeport, Connecticut, and Indianapolis, Indiana • In Canada: Noranda Copper and Brass Limited, Montreal

Improvements and economies in welded piping result from this *Variety* of

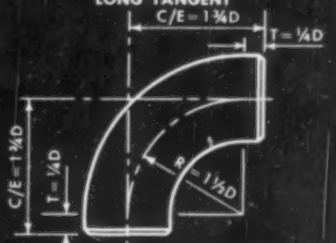
MIDWEST ELBOWS

1 LONG RADIUS ASA

SIZES: ¾" TO 24", INCLUSIVE

Dimensions conform to applicable size range of American Standard for Butt-Welding Fittings, ASA B16.9. Radius and center-to-end dimension equal 1½ times nominal pipe size.

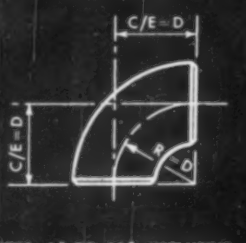
2 LONG RADIUS LONG TANGENT



SIZES: 2" TO 20", INCLUSIVE

Same radius as ASA Elbows but with long integral tangent on each end — an exclusive Midwest feature that saves time and pipe. No price increase over ASA Elbows.

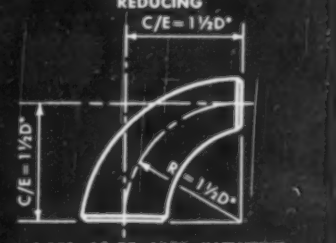
3 SHORT RADIUS



SIZES: 1" TO 30", INCLUSIVE

Where space limitations prevent use of ASA Elbows or Midwest "Long Tangent" Elbows shown above at right, these short turn elbows without tangents are recommended.

4 LONG RADIUS REDUCING



SIZES: 2" TO 12"*, INCLUSIVE

Midwest Reducing Elbow takes the place of a straight elbow and a reducer. It saves more than one-third of the welding and improves both design and appearance.

SYMBOLS { *C/E—Center-to-End Dimension* / *T—Length of Tangent* }

D—Nominal Pipe Size *R—Radius*
**D—Dimension is for larger Pipe Size*

The *variety* of Midwest Welding Elbows is particularly important because of the exceptional latitude in design and economy in erection that it provides. For example, the Midwest Long Tangent Elbow permits faster, easier, more accurate lining up with pipe . . . removes weld from point of maximum bending stress . . . often eliminates a short nipple and its extra weld. Slip-on flanges are easily used with minimum change in flange and fitting.

This "Variety" is only one of several reasons why many users prefer Midwest Welding Elbows.

MIDWEST WELDING FITTINGS

Improve Piping Designs and Reduce Costs

90° ELBOWS

REDUCING 90° ELBOWS

45° ELBOWS

LAP-JOINT STUB ENDS

REDUCERS

CAPS

SADDLES

SLEEVES

RETURN BENDS

TEES

LATERALS

CROSSES

REDUCING-ON-RUN TEES

SHAPED NIPPLES

FLANGES

Only MIDWEST offers this VARIETY

MIDWEST PIPING & SUPPLY CO., Inc.

Main Offices: 1450 South Second Street, St. Louis (4), Mo.
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Chicago (3), 79 West Monroe St. • Los Angeles (33), 520 Anderson St. • Houston (2), 229 Shell Bldg. • Tulsa (3), 533 Mayo Bldg. South Boston (27), 426 First St. • Distributors in Principal Cities.

Precision Produced

...from Globe Seamless Steel Tubes to Globe Welding Fittings

Your preference for Globe Welding Fittings is supported by a source of supply with exceptional qualifications. Specialized metallurgical experience and facilities gained in years of steel tubing manufacture enable Globe to produce welding fittings by a precision process that yields a superior product.

Send for the Globe Welding Fittings Catalog.

GLOBE STEEL TUBES CO.
Milwaukee 4, Wisconsin

Producers of Globe seamless stainless steel tubes — Gloweld welded stainless steel tubes — carbon — alloy — seamless steel tubes — Globeiron seamless high purity ingot iron tubes — Globe welding fittings.

GLOBE
PRECISION PROCESS
WELDING FITTINGS

ASK STOKES

We produce it...Apply it...Measure it

WE? Stokes! IT? High Vacuum!

STOKES is the source of complete information on every phase of vacuum operation. We do research and testing on vacuum up to one hundredth of a micron . . . on drying, freeze-drying, extraction, impregnation . . . on every process in which vacuum or high vacuum is, or may be, used.

Experience and demand have made Stokes the leader in the vacuum field. We make the Stokes Microvac Pump which creates almost exactly nothing. We make the Stokes High Vacuum Gage for accurate vacuum measurement. We make the Stokes Vacorder for use when vacuum must be continuously recorded. And we make the processing equipment in which vacuum is fundamental to the process or the result.

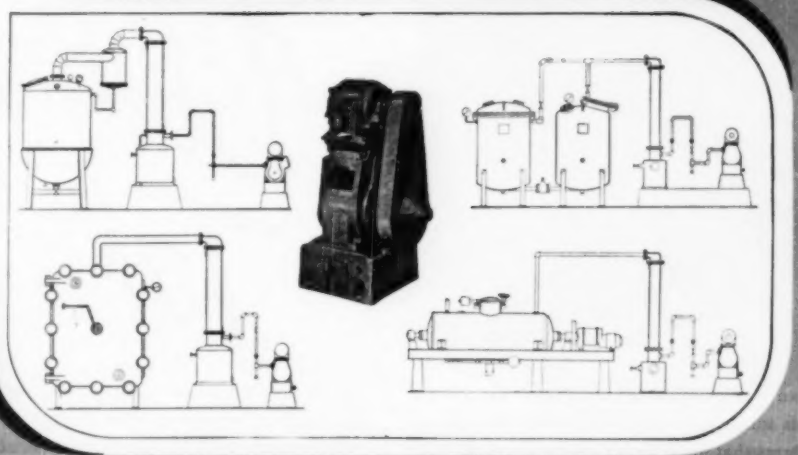
As pioneers and constant workers in the high vacuum field we maintain complete laboratory and semi-plant-scale equipment, with Advisory Service in the hands of skilled engineers, widely experienced in all fields related to chemical processing.

Stokes semi-plant-scale laboratory and Advisory Staff are at your service for problems outside the scope of your own staff or equipment. We invite consultation.

F. J. Stokes Machine Company, 5920 Tabor Road, Philadelphia 20, Pennsylvania

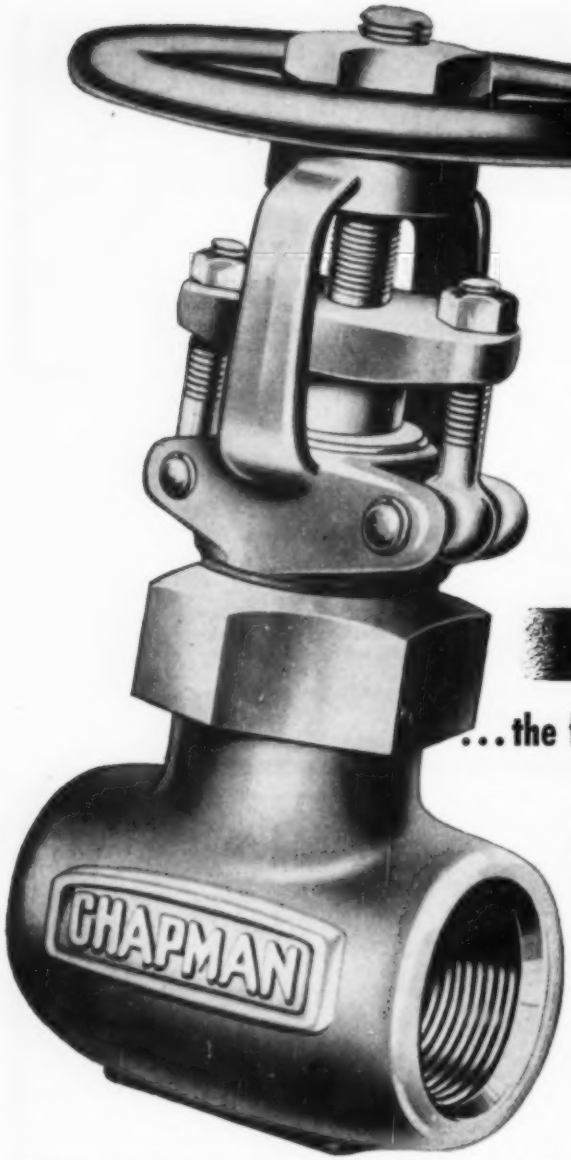
FJS

Stokes makes Vacuum and Special Processing equipment, High Vacuum Pumps and Gages, Pharmaceutical equipment, Industrial Tabletting and Powder Metal Presses, Plastics Molding Presses, Water Stills, and Special Machinery



Stokes Microvac pump with typical vacuum applications . . . Distilling, Impregnating, Shelf and Rotary Drying.

STOKES KNOWS HOW



Chapman List 960

...the forged steel gate valve that's

Built to Take it

Chapman was thinking of *your needs* when it designed this sturdy gate valve. That's why there are so many features that mean lower maintenance costs... longer years of useful life.

Take for instance the materials. There's tough forged steel in body and yoke... stainless steel in seat rings and plugs. Discs are not just hardened... they are superhardened by Malcomizing.

But that's only part of it. This valve is designed so you can repack it under full pressure... so that yoke threads are protected against rust and corrosion. And designed without gaskets to blow.

It's available in sizes from ¼" to 2"... carbon steel for pressures to 800 pounds; alloy steel for pressures to 1000 pounds at 750° F. For higher pressures, specify List 990.

The CHAPMAN Valve Mfg. Co.
INDIAN ORCHARD, MASS.

Permutit's WATER BARGAIN!

Slash costs up to 95%

Replace high-priced distilled water with Permutit's low-cost demineralized water

Compare costly, sparingly used distilled water with Permutit's Demineralized Water . . . it's up to 95% cheaper . . . it's a bargain that's good for nearly as many uses as distilled.

In Permutit's Demineralizing process, Zeo-Karb H®, Permutit's acid regenerated organic cation exchanger, replaces metallic cations in the water with hydrogen ions, converting the salts present into corresponding acids. These acids are then removed from the water by De-Acidite®, a resin type anion exchanger.

For full details on this economical demineralized water write to The Permutit Company, Dept. CE-5, 330 West 42nd Street, New York 18, N. Y., or to the Permutit Company of Canada, Ltd., Montreal.

Permutit®

WATER CONDITIONING • ION EXCHANGERS • MATERIALS & EQUIPMENT

Struthers Wells

RADIAL PROPELLER Agitator

The *Economical* Solution

for BLENDING LIQUIDS
DISSOLVING SOLIDS IN LIQUIDS
MIXING GASES WITH LIQUIDS
AERATING
GASIFYING
OPERATED IN ANY TYPE
OPEN OR SEALED VESSEL

A complete range of agitator drives is offered in ranges of speed from 10 RPM to 500 RPM; from fractional to 50 H.P. with stuffing boxes or mechanical seals for pressures up to 300 pounds or more.

Quick opening manhole for inspection or filling.

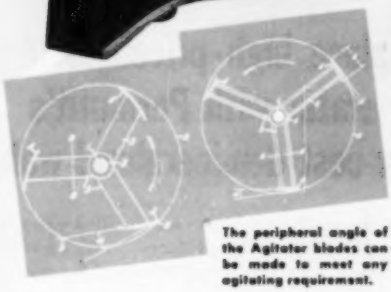
Semi-flexible coupling protects the shaft supporting bearings from bending movements of the extended agitator shaft.

Vertical baffles may be supported by means of a nozzle in the top head thereby eliminating pockets in which materials may accumulate and providing easy outside adjustment.

The radial propeller agitator is simple in design, efficient in performance, and self-cleaning in operation.

Struthers Wells flush bottom valves are available in several sizes in all commercial alloys.

The removable feature of the Struthers Wells bottom guide bearing simplifies maintenance and replacement.



The peripheral angle of the Agitator blades can be made to meet any agitating requirement.

The diagrammatic illustration at the left shows the Propeller Agitator mounted in a Struthers Wells heavy duty stainless steel mixer. Propeller Agitators are available in all commercial sizes, and can be specifically designed for any practical liquid agitating requirement.

Write for Bulletin 52-W.

STRUTHERS WELLS
Corporation
PROCESS EQUIPMENT DIVISION
WARREN, PENNA.
Plants at Warren, Pa. and Titusville, Pa.

D.O.James

ESTABLISHED 1888

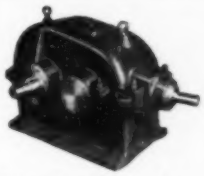
GEARED DRIVES MEET GROWING DEMANDS FOR POWER-SAVING EQUIPMENT IN INDUSTRY

Continuous-tooth Herringbone
Single, Double, Triple Reduction

Type "H" Worm Gear

Straight Line Gear Reducer

Motorized Reducers



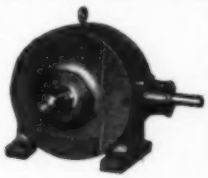
Spiral Bevel Herringbone

Double Worm Gear

Helical Worm Gear

Motorized Worm Gear

Right Angle Gear Reducer



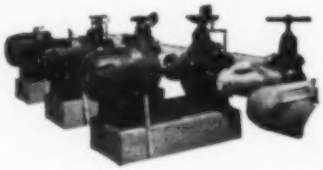
Spiral Bevel Gear

D.O.James Gear Manufacturing Co. is constantly developing and continuing to improve its variety of gear speed reducers—enabling engineers and designers of power-saving equipment to meet and cope with space limitations, horsepower requirements, ratios, location of driven or driving shafts and the type of drive that the many and varied installations require. Catalogs are available containing complete informative engineering data that will assist in the selection of the type of reducer for the specific job to be done.

D.O.JAMES GEAR MANUFACTURING CO.

Since 1888—Makers of Cut Gears, Gear Reducers and Flexible Couplings

1140 W. MONROE STREET • CHICAGO, U. S. A.



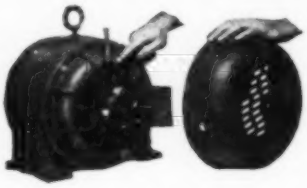
How do

ON MOTORS

Q. As applied to a motor, what does "explosion-proof" actually mean?

1) *That the motor's operation is not affected by external nearby explosions?*
2) *That gastight construction prevents entry of gas or vapors that might explode inside the motor?*
3) *That the motor's enclosure withstands internal explosion and keeps sparks from escaping outside?*

A. An explosion-proof motor (Class I Group D) has an enclosure which will withstand an explosion of a specified gas or vapor which may occur within it, and prevent resulting sparks, flashes, or explosions from igniting the specified gas or vapor surrounding the motor. G-E makes the most complete line of motors tested and listed by UL for hazardous locations in chemical plants—in some cases, the only ones so listed. See Bulletin GEA-4131.



Q. What's the newest development in corrosion resistance for chemical plant motors?

1) *A newly developed paint immune to acids and alkalies?*
2) *A new type of cooling fan?*
3) *A special grease lubricant for ball-bearings?*

A. It's G-E's new Textolite® corrosion-resistant cooling fan, now supplied in all Tri-Clad® totally enclosed fan-cooled motors in ratings from 1 to 15 hp. Added to Tri-Clad's corrosion-resistant cast-iron enclosure, the new fan now makes these standard, off-the-shelf motors available for chemical plant service regardless of the acids and alkalies that may be encountered. It's nonsparking, too, and tested and listed by UL for use in explosion-proof motors for hazardous areas Class I Group D, and Class II Groups E, F, and G. Send for Bulletin GEA-4400 on Tri-Clad totally enclosed motors.

Q. If you were placing low-voltage control in a hazardous or semi-hazardous location, what equipment would you specify?

1) *Separate units and wall-mount?*
2) *Circuit breakers separate from starters?*
3) *A factory-assembled group unit?*

A. The convenient, time-saving way is to specify a racked-up assembly of G-E combination starters and breakers designed especially for indoor or outdoor chemical plant use. It's a standard, factory-built arrangement, with all control units mounted on a self-supporting framework. Available are corrosion-resisting, oil-immersed, and air-break explosion-proof types, the last two for Class I, Group D locations. Bulletin GEA-3541 gives data on oil-immersed starters.

GENERAL ELECTRIC

you rate AND CONTROL ?

Q. When you want to combine high-voltage motor control with short-circuit protection in a semi-hazardous area, what do you do?

1) *Order circuit breakers magnetic starters, and overload relays separately?*
2) *Specify group-assembled controllers as one unit?*
3) *Install magnetic starters and provide for short-circuit protection by means of separate safety switches?*

A. You would do best by specifying high-interrupting capacity G-E Limitamp controllers, with sealed current limiting fuses which serve both as fuses and disconnect switches. Contactors are oil immersed or in explosion-proof cases. These compact units are completely wired ready to be quickly and inexpensively installed. They are furnished as single units or as a complete group of several units, including incoming oil-circuit breakers and transformer feeders. Check Bulletins GEA-4247 and GEA-3660.

Q. For what reason would you specify a motor control center?

1) *It saves space?*
2) *It simplifies future expansion?*
3) *Easy installation and maintenance?*

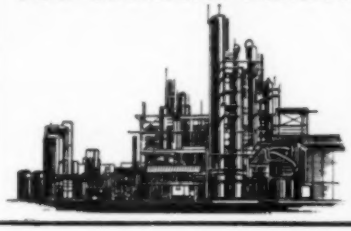
A. All three features characterize the new G-E motor control center, with which you can plan the right combination for your plant's needs. Compact, self-enclosed starting units (in four size ranges, from NEMA size 1 to 4, inclusive) fit interchangeably within vertical sections. Front-connected wiring simplifies installation, changes and maintenance. Sections can be placed back to back or against a wall to utilize available plant space. Bulletin GEA-4979 describes the new G-E motor control center.

G.E. MAKES DOUBLY SURE YOU GET THE RIGHT ELECTRIC EQUIPMENT

Bring your questions on the selection of motors and control to General Electric. For G.E., over the years, has developed the most complete line of electric equipment to meet specialized chemical plant needs. What's more—to make doubly sure your selection is correct—G.E. teams up two or more engineers to advise you. Specialists who know their particular lines of electric equipment inside out work hand in hand with an "industry" man who is thoroughly at home with chemical plant practice and electrical needs. With their pooled knowledge and experience to draw on, you're certain to meet your requirements practically, economically. Check your nearest G-E office and help yourself to this "extra." For more information on motors and control, send in the coupon.

MOTORS AND CONTROL

FOR CHEMICAL PLANTS

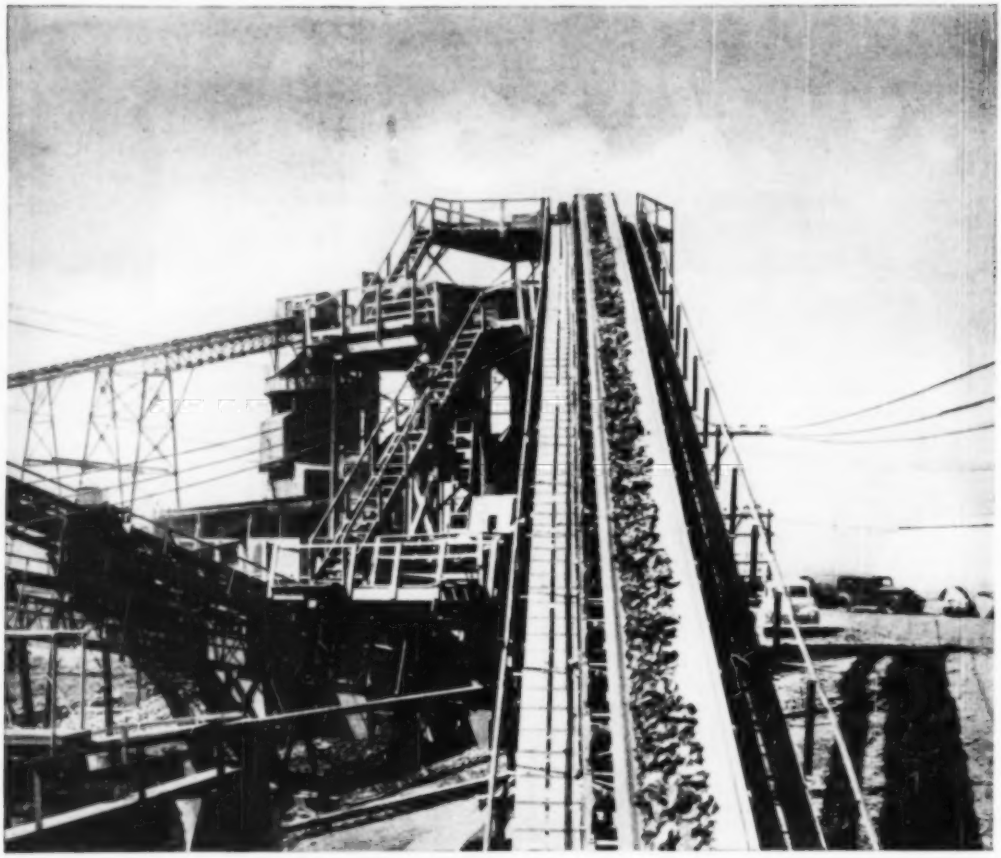


General Electric Company, Section F662-30
Apparatus Department, Schenectady 5, N. Y.

Please send me the following information on G-E motors and control for refineries.

- ..... *GEA-4131—Motors and control for hazardous locations*
- ..... *GEA-3541—Oil-immersed starters*
- ..... *GEA-4400—Tri-Clad totally enclosed fan-cooled motors*
- ..... *GEA-3660—Limitamp controllers with oil-immersed contactors*
- ..... *GEA-4247—Limitamp controllers with air-break contactors*
- ..... *GEA-4979—Motor control center*

Name .....
Company .....
Address .....
City ..... State .....



Why stepped-ply construction steps up belting life

One big reason why you get longer service life with this Hewitt Belting is the way it's made.

Its stepped-ply construction means that extra plies of strong duck have been added along both edges. And it means that a shock-absorbing layer of thick rubber cushioning has been added to the middle of the belt.

This construction provides maximum resistance to heavy impacts. It also gives you ample protection against the steady abuse which idlers frequently inflict upon conveyor belting.

Thus Hewitt not only gives you the utmost in belting strength, but better troughing as well!

And because it troughs naturally, this extra-quality belting runs true along the idlers . . . is less vulnerable to damage from loading chutes or idlers.

"Stepped ply" construction assures natural troughing . . . less material "spill."
Solid cushion of rubber absorbs shock of heavy impacts . . . thickest where most needed.
Transverse "breaker" strip strengthens carcass . . . prevents cover from stretching beyond elastic limit.

So insist on Hewitt for all *your* conveyor belting needs, whether standard, stepped-ply, or cord construction. Just call the Hewitt distributor listed in the yellow pages of your telephone directory. Or write Hewitt Rubber Division, 240 Kensington Ave., Buffalo 5, N.Y.

HEWITT RUBBER DIVISION
INDUSTRIAL HOSE AND BELTING

HEWITT
CONVEYOR BELTING

HEWITT-ROBINS INCORPORATED

You Get Commercial Chemicals with Laboratory Purity . . .

When You Order Hooker Sulfides

With a maximum iron content of only 8PPM in Hooker Sodium Sulfide and only 5PPM in the Sodium Sulfhydrate you can understand why we are proud of the purity of these Hooker Sulfides. This minute amount of iron is matched by an especially low amount of other impurities in these Hooker products.

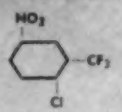
Packaged in the form of small flakes, both products are quickly and completely soluble in water. The clear solution can be used without settling or decanting. For smooth reactions—for good yields without troublesome side reactions from impurities, your safest course is to use Hooker Sulfides.

Advanced manufacturing techniques, carefully controlled operations, carefully selected raw materials account for Hooker's ability to produce these pure sulfides on a commercial basis.

As an added convenience for those who use sodium sulfhydrate in large quantities this chemical is also available in liquid form in tank car quantities. Liquid sodium sulfhydrate is shipped in concentrations of approximately 37% or 45%. Specifications will be furnished upon request.

Technical Data Sheets and samples will be sent to qualified personnel making requests on their business letterheads.

HOOKER RESEARCH PRESENTS
2-CHLORO-5-NITROBENZOTRIFLUORIDE



Synonym	2-chloro-5-nitrotrifluoromethylbenzene
Molecular Weight	225.56
Freezing Point (c.p.)	16.8°C
Boiling Point	230.0°C
Refractive Index n20/D	1.5009
Specific Gravity, 25/15.5°C	1.5330

Another new development of Hooker Research in benzotrifluorides is 2-chloro-5-nitrobenzotrifluoride. It is a straw colored, thin, oily liquid. Because this chemical is so new, information available on its uses is limited. Literature does indicate however, its use as an intermediate in the preparation of dyestuffs.

Hooker 2-chloro-5-nitrobenzotrifluoride is at present available in pilot plant quantities.

Those who are interested in investigating the potentials of 2-chloro-5-nitrobenzotrifluoride may obtain samples by writing on their business letterheads. Technical Data sheets giving more complete physical and chemical information are also available.

DESCRIPTION	ANALYSIS	USES
SODIUM SULFIDE Na_2S Mol. Wt. .... 78.1 M. P. ..... 100°C Light buff colored solid in flake form. Rapidly soluble in water; slightly soluble in alcohol; insoluble in ether.	Na_2S ..... 60 to 62% NaCl ..... 1.5% Max. Other Na Salts ..... 2.0% Max. Fe ..... 8 ppm Max. Cu, Ni, Cr, Mn, Pb ..... 1 ppm Max. Water of crystallization ... 36.5 to 34.5%	In unhairing hides and wool pulling; desulfurizing viscose rayon; in manufacture of dyestuffs, chemical intermediates, paper pulp, soap and rubber, as an ingredient of dye liquor for textile dyeing; boiling out linen; ore flotation and metal refining. SHIPPING CONTAINERS Steel drums ..... 90 and 350 lbs. net
SODIUM SULFHYDRATE NaSH (sodium hydrosulfide) Mol. Wt. .... 56.1 M. P. ..... 55°C Light lemon colored solid in flake form. Completely and rapidly soluble in water, alcohol and ether.	NaSH ..... 70 to 72% Na_2S ..... 2.5% Max. NaCl ..... 0.8% Max. Na_2SO_3 and $NaHCO_3$ ..... 0.4% Max. Fe ..... 5 ppm Max. Cu, Ni, Cr, Mn, Pb ..... 1 ppm Max. Water of crystallization ..... 28 to 26%	In unhairing hides, in desulfurizing viscose rayon; in preparation of dyestuffs and other organic chemicals such as thioamides, thiourea, thioglycolic acid, thio- and dithiobenzoic acids, sodium thiosulfate. SHIPPING CONTAINERS Flake: Lacquer-lined steel drums . 90; 350 lbs. net Liquid: Tank Cars .....

From the Salt of the Earth

HOOKER ELECTROCHEMICAL COMPANY

HOOKER CHEMICALS

5 FORTY-SEVENTH ST., NIAGARA FALLS, N. Y.

NEW YORK, N. Y. • WILMINGTON, CALIF. • TACOMA, WASH.

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SODIUM SULFIDE • SODIUM SULFHYDRATE • SODIUM TETRASULFIDE • CAUSTIC SODA • MURIATIC ACID • PARADICHLOROBENZENE • CHLORINE

HERE IS A 3-STEP PLAN for cutting processing costs

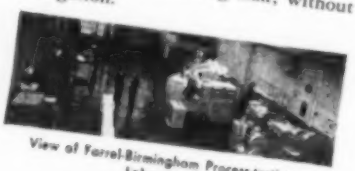
1

EXPLORE BY EXPERIMENT **the possibilities of new processing techniques.**

The Farrel-Birmingham process-testing laboratory provides the ideal spot for conducting such experiments.

Here, there are numerous pieces of modern equipment in both laboratory and production sizes. This equipment is designed to help work out processing techniques *before* beginning full-scale production. Interchangeable working elements for these machines, and a wide range of speeds and pressures, broaden the scope of their use, making a great variety of tests possible.

Farrel-Birmingham offers the private use of this laboratory and the assistance of its engineering staff, without obligation.



View of Farrel-Birmingham Process-testing Laboratory

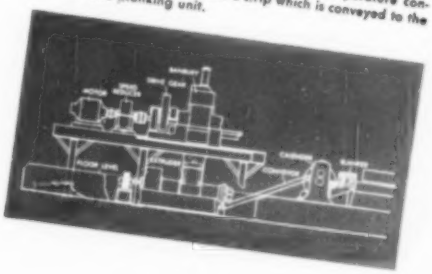
2

ENGINEER YOUR PLANT LAYOUT **to provide an efficient, continuous flow of production.**

For many years, Farrel-Birmingham has made a specialty of engineering complete processing setups. Developed from start to finish by company engineers, each of these layouts is composed of production machines *matched in capacity* to prevent the "choking" or "starving" of succeeding units. Production flows without costly interruptions and with manual aid and supervision reduced to a minimum.

The Farrel-Birmingham *Engineering Planning Division* is staffed by men with a background of many years of experience in solving processing problems for the rubber and plastics industries.

Setup especially designed for the production of blanks from which phonograph records are made. In operation the 12" extruder receives stock directly after it has been processed in a Banbury mixer. The extruder, which requires no operator, handles the full capacity of the Banbury. The stock is thoroughly worked by screw action under close temperature control, and the die head extrudes a strip which is conveyed to the calender and blanking unit.



3

SELECT EQUIPMENT *to suit needs exactly.*

Farrel-Birmingham production units are available in various sizes and with a wide choice of design features to meet specific requirements.

BANBURY MIXERS—First developed for the rubber industry where its use is virtually universal, the Banbury is now widely used with equal efficiency in the production of plastic materials such as phenolic condensation products, cellulose acetates, caseins, synthetic resins, vinyl chloride resins; also asphalt roofing and flooring, linoleum, paints and lacquers.

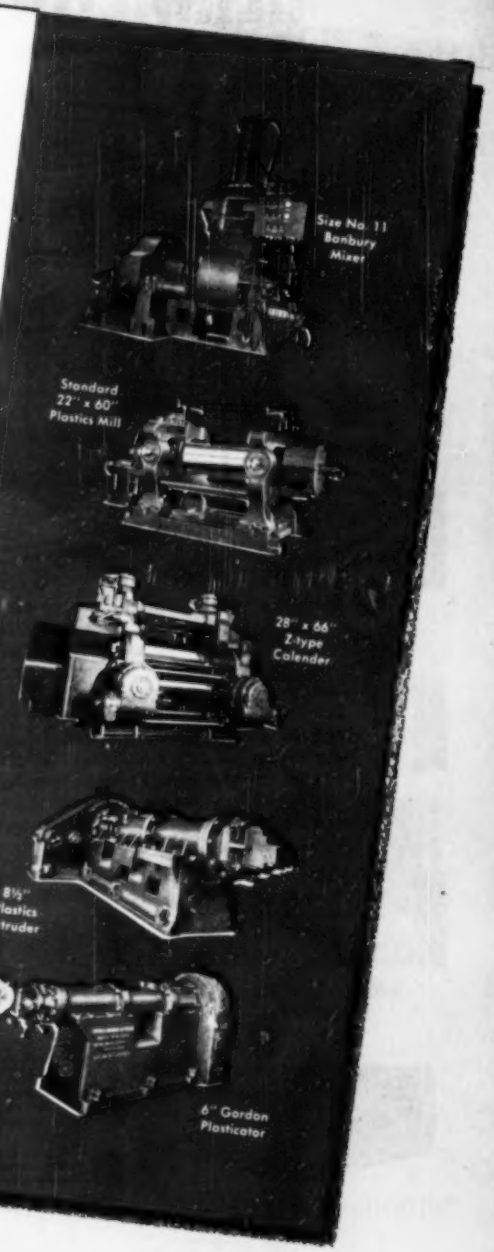
Banbury mixers are made in six standard sizes for processing plastics, from the size B for laboratory or small production work to the No. 11 with its net chamber capacity of 14,940 cubic inches.

MILLS — Farrel-Birmingham mills provide close temperature control and accurate gauge where these are required for processing synthetic materials. Mills are available in a complete range of sizes, from 6" x 13" for the laboratory up to 28" x 84" heavy duty machines for the factory. For special requirements, variations in design as well as a wide choice of drive arrangements are obtainable, often from existing plans.

CALENDERS—Farrel-Birmingham calenders are designed for the highly specialized work of calendering plastics, a continuous, high-speed operation that demands accurate control of gauge for satisfactory production. From the small laboratory units to the huge production sizes, the physical proportions, materials, type of construction, lubricating system, gearing, special operating features—in fact, every detail is designed to fit the job the calender is built to do. Calenders are available in both Z-type and inverted L-type constructions.

EXTRUDERS—Farrel-Birmingham extruders have "designed-in" features and construction to suit each machine for its particular function. They are built in a range of sizes from 6" to 20" for a variety of applications in processing plastics stocks.

Gordon plasticators, which are used for continuous mixing of the various powders or granules that go into numerous thermoplastics, are available in 6", 8½", 12", 15" and 20" production sizes and a 3" laboratory size.



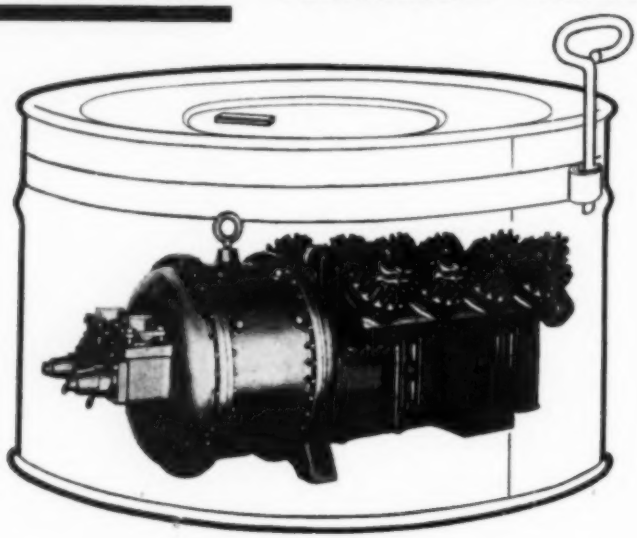
Before you purchase new processing equipment, call in a Farrel-Birmingham engineer. He will be glad to give you the details of this 3-step plan for cutting processing costs.

FARREL-BIRMINGHAM COMPANY, INC. • ANSONIA, CONNECTICUT

Plants: Ansonia and Derby, Conn., Buffalo, N. Y.
Sales Offices: Ansonia, Buffalo, New York, Boston, Pittsburgh, Akron, Chicago, Los Angeles, Tulsa, Houston

Farrel-Birmingham

"HERMETIC" MEANS AIRTIGHT



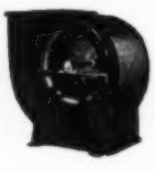
No other air conditioning compressor can match the Westinghouse record of dependability. Because this *hermetically-sealed* compressor means no costly refrigerant leaks. It also means that system-damaging grit, moisture, rust and corrosion are *sealed out.* Westinghouse pioneered the development of the *hermetically-sealed* compressor and direct drive for power economy—no belts, no pulleys, no shaft seals. Power is provided by a sealed-in, Westinghouse Life-Line motor—famous in its own right as stronger, longer-lived and trouble-free.

These facts mean better air conditioning performance, longer over-all life, fewer breakdowns . . . lower maintenance costs. Thousands of installations, from 1 to 500 HP, have proved that the Westinghouse *hermetically-sealed* compressor gives *you* more for your air conditioning dollar. It'll pay to check with your nearest Westinghouse Air Conditioning Distributor. Or, write to the Westinghouse Electric Corporation, Sturtevant Division, Hyde Park, Boston 36, Massachusetts.

Westinghouse
Sturtevant Division

AIR HANDLING UNITS

UNIT HEATERS



CENTRIFUGAL FANS

AXIAL FLOW FANS

...THAT'S WHY THE WESTINGHOUSE HERMETICALLY-SEALED COMPRESSOR MEANS MORE FOR YOUR AIR CONDITIONING DOLLAR

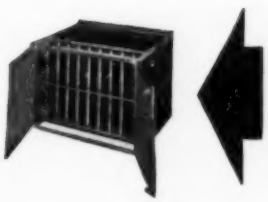
REFRIGERATION COMPRESSORS

EVAPORATIVE CONDENSERS

HEATING AND COOLING COILS

UNIT AIR CONDITIONERS

BLOWER HEATERS



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Everything that puts air to work for Every application

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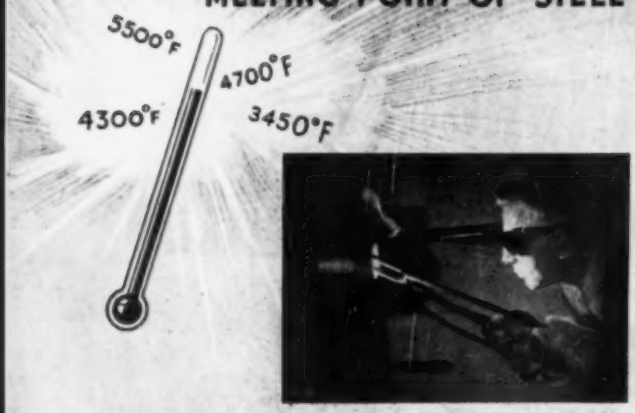
TEMPERATURES *TWICE* THE MELTING POINT OF STEEL!



Industry Uses These Temperatures Today . . . with Norton-Developed Refractories

TEMPERATURES as high as 4300° F. for sintering carbides . . . up to 4700° F. in the manufacture of acetylene . . . even up to 5500° F. in certain research projects . . . that's the trend in industry today, toward higher and higher temperatures.

High temperatures call for special refractories in which Norton Company has been pioneering for 36 years. As in many industries, the process industry also is turning to Norton for special refractories to handle today's super temperatures. Outstanding in high temperature operations are Norton's pure oxide refractories of thoria, zirconia, fused magnesia (MAGNORITE*) and fused alumina (ALUNDUM*).

In addition to handling super temperatures in process plants, Norton refractories are handling heat for many industries—metal; ceramic; power and gas generating.

*Trade-mark reg. U. S. Pat. Off.

The main Worcester plant of Norton Company

NORTON REFRACTORIES LIKE HEAT

NORTON COMPANY, WORCESTER 6, MASS.

Piccolyte

the Versatile Resin

gives you all this and LOW COST TOO!

- Light Lemon Color
- Color is Stable
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- No Acidity
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- Solubility in Aliphatic Naphthas
- Thermoplastic

This highly-useful pure hydrocarbon thermoplastic terpene resin provides many desirable qualities, as indicated by the list above. Piccolyte is low in first cost, and soluble in low cost solvents. It is compatible with waxes, oils, bituminous materials, resins and other substances. It is high in quality, and dependably uniform.

WRITE for free sample and data book giving complete details. Please describe your application in your inquiry.

PICCO

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Makers of Coumarone Resins • Coal Tar Solvents • Styrene Resins • Rubber Plasticizers • Reclaiming Oils • Terpene Resins • High Solvency Naphthas • Solvent Oils

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Please send me a free sample of Piccolyte, and your new bulletin. I wish to investigate Piccolyte for (application).....

Name.....

Company.....

Address.....

(CE)

BWH
DEPENDABLE RUGGEDNESS
Bull Dog Industrial V-Belts are available in A, B, C, D and E sections. Full range of lengths
Fractional Horsepower (FHP) V-Belts are available in three standard sections. Full range of lengths

LESS SLIPPAGE! COOLER RUNNING! LONGER LASTING!

NO WONDER THERE'S INCREASING DEMAND FOR

RUGGED BULL DOG V-BELTS

On tough jobs where a dependable V-Belt drive is of utmost importance, operators today are specifying Bull Dog V-Belts.

These new BWH "titans" have consistently proved they deliver the kind of steady, trouble-free service that speeds production and slashes maintenance costs.

Here's why there's less slippage with Bull Dog V-Belts, fewer shutdowns for adjustments, greater long-term economy in their use:

1. *Exclusive Bull Dog Cord Section Has Higher Tensile Strength,* able to carry the load and absorb shock.

2. *Low Stretch,* because exclusive Bull Dog Cords are processed in a new way. As a result, there's less slippage, fewer adjustments, longer belt life.

3. *Cool Running,* thanks to quality-controlled compounds developed in BWH laboratories, which do not crack or deteriorate under the most severe flexing.

4. *Wear-Resistant Covers* of heavy, bias-cut fabric, to protect heart of belt from dirt, grease and moisture.

Bull Dog V-Belts are one of many famous products manufactured by BWH. When you need industrial rubber goods, look to BWH for products of dependable ruggedness, to BWH distributors for dependable service.

HAVE YOU A JOB WHERE STAMINA COUNTS?
Bring us your toughest problems. We're specialists in solving them. Consult your nearby BWH distributor or write us direct.

Another Quality Product of

BOSTON WOVEN HOSE & RUBBER COMPANY

Distributors in all principal cities

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FOR HIGH PRODUCTION

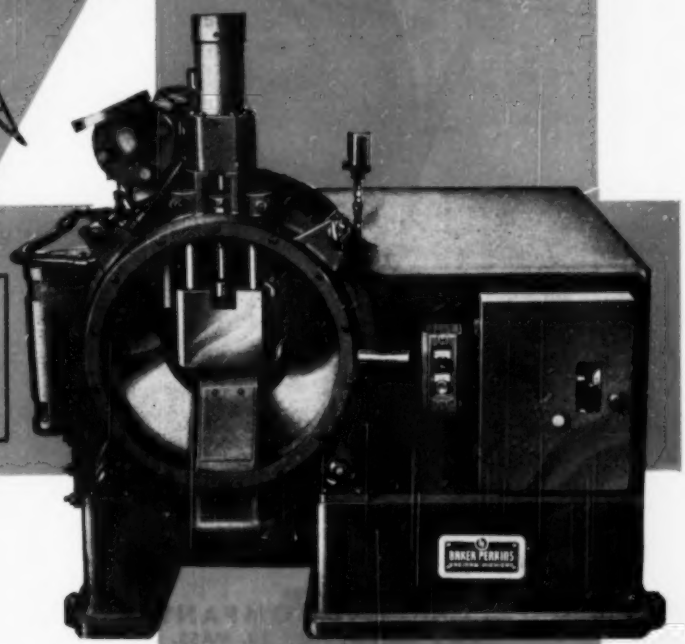
of filterable slurries . . . four sizes of the new

BAKER PERKINS type H ter Meer Centrifugals

● Now available for production — as well as the laboratory — are four sizes of the new Type H ter Meer Centrifugal for high production of filterable materials. Continuous and completely automatic, these centrifugals may be operated on cycles of from 30 seconds to 30 minutes, depending on the nature of the product being centrifuged. Free draining crystalline material frequently can be handled at a rate from 5 to 700 cu. ft. of solids per hour.

● An important feature of these continuous ter Meer Centrifugals is the wide range of retention time, making them adaptable to many types of materials from free draining crystalline to finest filterable solids. Totally enclosed, vapor-tight construction is available to prevent escape of solvents. Standard models are constructed of stainless steel, special models made of suitable metal to meet particular requirements. Write for complete information.

Size Centrifugal	Capacities cu. ft. per hour	Horsepower required	Net Weight
H-18	5-40	3	2,000 lbs.
H-24	25-100	7½	4,500 lbs.
H-36	75-300	15	7,800 lbs.
H-54	250-700	30	18,500 lbs.



BAKER PERKINS INC.

CHEMICAL MACHINERY DIVISION, SAGINAW, MICHIGAN

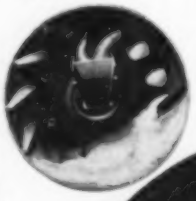
STURTEVANT

Dustless BLENDERS

Produce Perfectly Mixed Products with NO Loss of Materials

RECEIVING

The ingredients to be mixed enter the mixing chamber of the drum through a chute. Note scoops which carry up and dump the ingredients as the drum rotates.



DISCHARGING

By simply throwing a lever, the inlet is closed and the mixer is in discharging position. The completely mixed materials drop off the lifting scoops and discharge through chute without segregation of ingredients.

Four-way mixing action produces homogeneous blends. No matter what the densities, weights, finenesses or other physical properties of the ingredients, Sturtevant Dustless Blenders provide *a thoroughly blended product* with no substances floating to remain unmixed. Sturtevant advantages include—single opening for both receiving and discharging . . . "open door" accessibility for quick, thorough cleaning . . . rugged construction for long life and minimum maintenance. Sturtevant Dustless Blenders are available in mixing capacities from 500 to 20,000 pounds. Write for information or engineering assistance.

STURTEVANT MILL COMPANY
100 CLAYTON STREET, BOSTON 22, MASS.

Designers and Manufacturers of

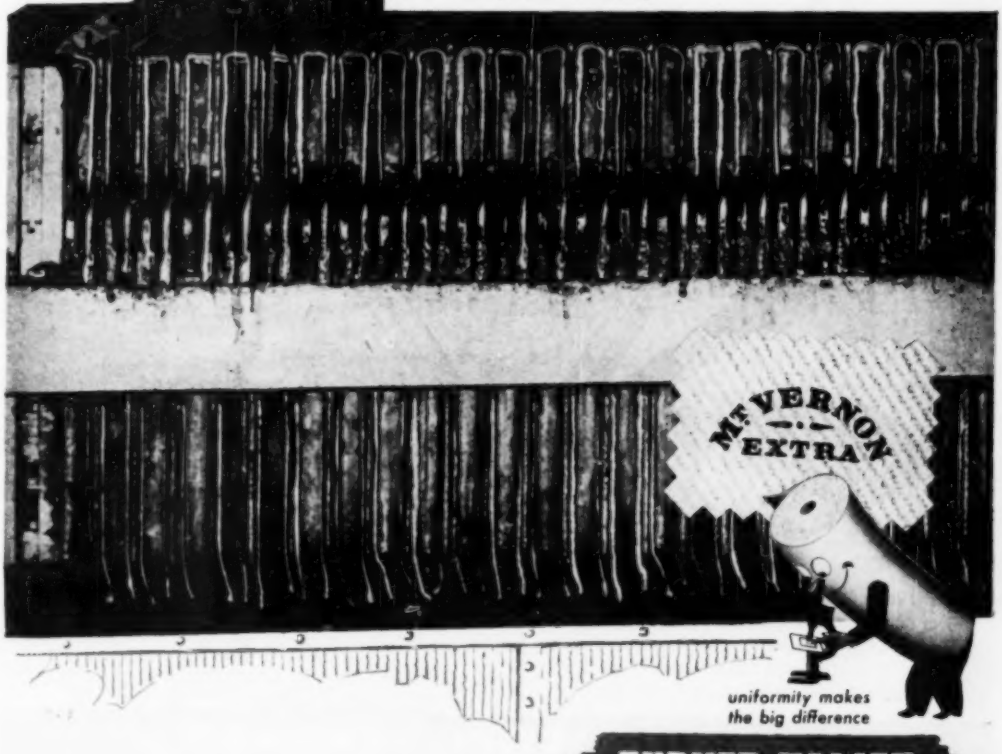
CRUSHERS • GRINDERS • SEPARATORS • CONVEYORS
MECHANICAL DENS and EXCAVATORS • ELEVATORS • MIXERS

Filter Fabrics that Fill the Bill ...Mt. Vernon Extra

There are few filtering problems that won't yield to a sound engineering approach and the right fabric. One of the functions of the laboratories and engineering staff of Mt. Vernon-Woodberry is to help solve such problems.

And to assure the right fabric, Mt. Vernon-Woodberry produces Mt. Vernon Extra filter fabrics from top grades of cotton, under strict laboratory controls, to a high degree of uniformity. Mt. Vernon Extra gives you greater clarification of filtrates, more efficient recovery of solids, reduced replacement costs.

Specify Mt. Vernon Extra—and get filter fabrics that give you longer wear and greater efficiency.



uniformity makes the big difference

Mt. Vernon-Woodberry Mills

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Spline Type Plugs mean flow control to the Last Drop!

"Fifteen" SPLINE TYPE SEAT GUIDED PLUGS are INTERCHANGEABLE in ½, ¾ and 1" Microflo Barstock Bodies. Trim is solid Stellite. The retained seat is type No. 12 and the plug is type No. 6 Stellite. The spline plug has a valve lift of 1", from the closed to the wide open position. Rangeability 50:1, or better, in all fifteen plugs. Equal percentage flow characteristics sizes No. 1 thru No. 5. Linear flow sizes No. 6 thru No. 15. Spline plug is a selective fit in a honed seat.

★ CONVERSION OF FLOW COEFFICIENT Cv TO CUBIC CENTIMETERS

Trim Size	Cv	CC
1	0.63	2383
2	0.40	1514
3	0.25	946
4	0.16	605
5	0.10	378
6	0.063	238.3
7	0.040	151.4
8	0.025	94.6
9	0.016	60.5
10	0.010	37.8
11	0.0063	23.83
12	0.0040	15.14
13	0.0025	9.46
14	0.0016	6.05
15	0.0010	3.78

★ The valve flow coefficient "Cv max." at one inch of lift, is equal to the rate of flow in GPM of water (or equivalent "cc") at one psi pressure drop across the valve body. The minimum flow will be 1/50 of Cv max., shown in the table.

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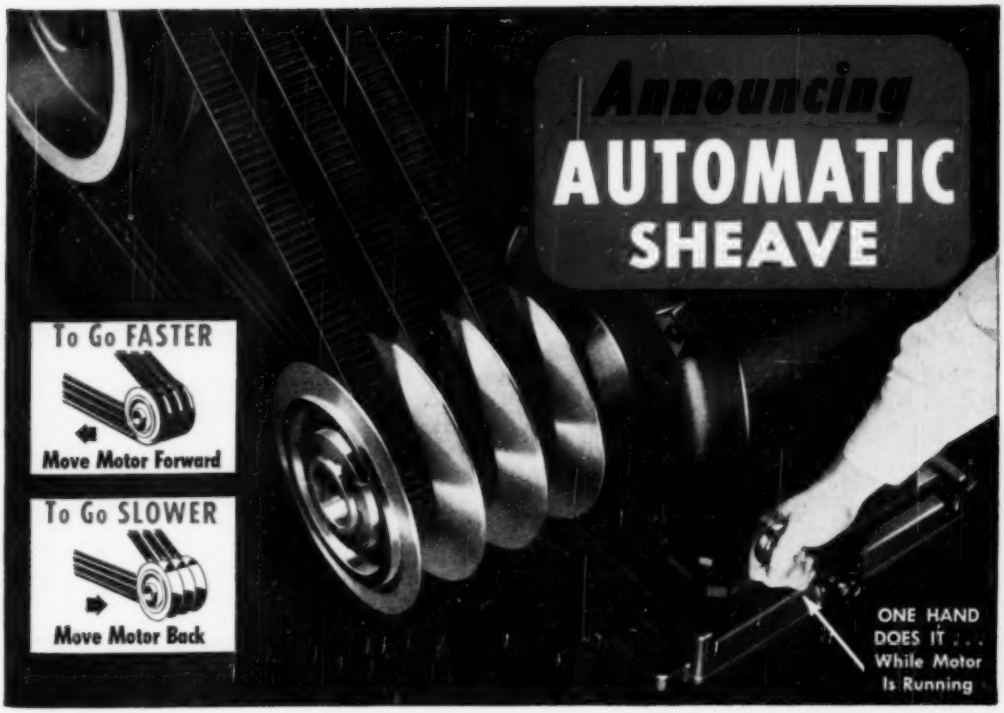

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- Instant speed control at lower cost than ever before
- Covers most speed changing needs from 3 to 20 hp
- Extremely simple — one sheave does all
- Infinitely variable speed — 200% range

SIMPLEST, most economical method of instant speed control ever devised. Simply move motor forward to increase speed and move it back to decrease. The new *Vari-Pitch* Automatic Sheave changes pitch diameter and holds belts at proper tension automatically. All other parts of the drive are standard *Texrope* V-belt drive components.

For details see your A-C Authorized Dealer or Sales Office or write for bulletin 20B7223. *Texrope* and *Vari-Pitch* are Allis-Chalmers trademarks.

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MOTORS — ½ to 25,000 hp and up. All types.

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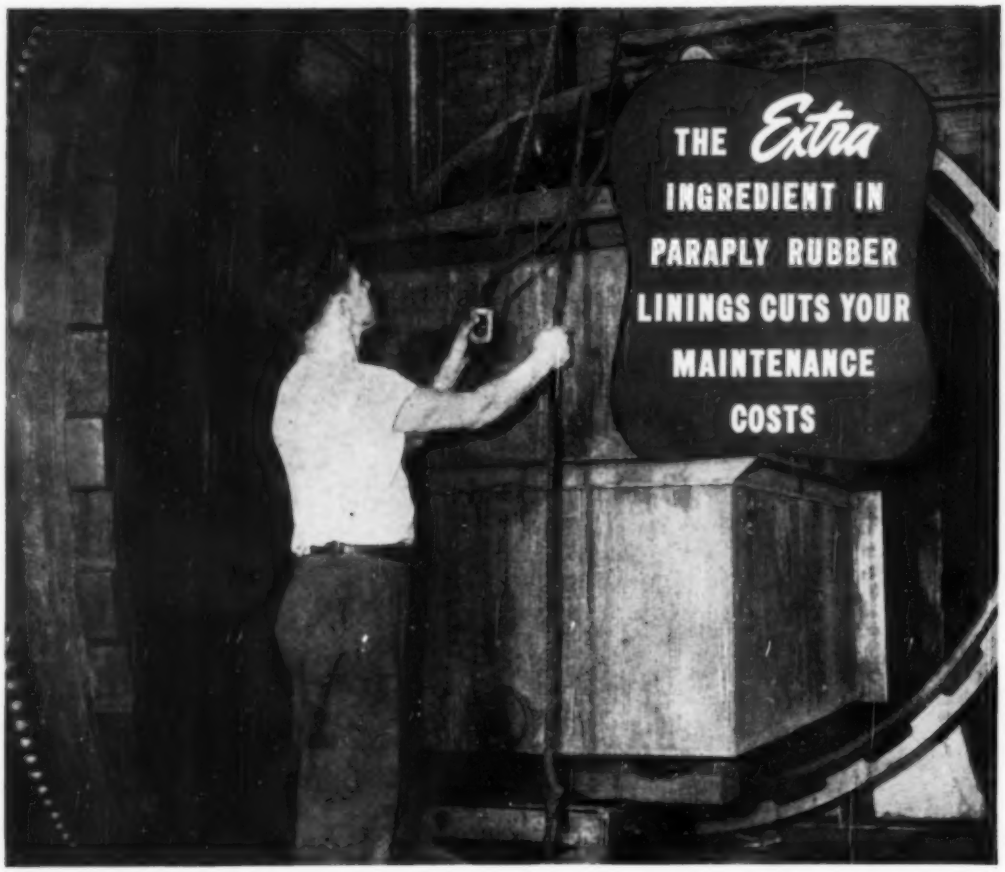

THE extra ingredient we put into Paraply Rubber Linings is not a new magic chemical. It is old fashioned CARE. Extra precaution is taken in every step of manufacture to be sure you get more for your money than you expect.

This extra precaution starts with the choice of the proper rubber compound, developed specifically if necessary to meet your needs. It continues with the process of application, in such things, for example, as the use of a specialized adhesive which not only gives high bond strength, but provides corrosion protection as well. Thus any accidental rupture will be localized and easily repaired.

Final testing of the completed job is rigorous and thorough. Before any Paraply Rubber-lined equipment leaves our plant, high voltage current scans every inch to detect the slightest flaw.

This added ingredient, *extra care*, costs you no more. It helps you keep your maintenance costs at a minimum level, and is assurance of a useful life much longer than you could normally expect.

In addition to rubber, U. S. Stoneware manufactures a wide range of corrosion-resistant materials, including Tygon and Duralon plastics, Resilon synthetics, sheet and homogeneous lead linings and lead-lined products, chemical porcelain, chemical stoneware, acid brick, and acid and corrosion-proof cements, as well as baked-on and air dry protective coatings. We can thus recommend without prejudice the material or combination of materials that will do the best job for you.

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COMMENTS ON THE NEWS OF CHEMICAL ENGINEERING IN INDUSTRY

May 1949, Volume 56, Number 5

For India, her own drugs

State-owned plant to manufacture penicillin, sulfa drugs and anti-malarials is to be built for India by the Swedish firm of Karnbolaget of Stockholm. The plant will be near Bombay.

Annual production expected: 1.2 billion units of penicillin, 60,000 lb. of sulfamerazine, 20,000 lb. each of sulfathiazole and sulfanilamide, and 100,000 lb. of anti-malarial drugs. Cost of the plant will be nearly $6 million, with production slated to begin within three years.

Savings for India will be almost $6.8 million a year, mostly in hard currency, when the plant gets going. At present, India has to import penicillin and the other drugs.

More Cuban molasses

Publicker has managed to wangle another advantageous contract out of the Cubans. This time, Publicker is to get 54 million gallons of molasses at 4c. a gal.

Not long ago the Cuban Sugar Stabilization Institute abruptly terminated a contract with Publicker. That contract called for delivery to Publicker of 80 million gallons of molasses. Price of the molasses was pegged to that of ethyl alcohol. About half of the molasses, or 40 million gallons, was actually delivered. And Publicker put much of it into inventory.

Now Publicker has what is left of the 40 million gallons it got under the old contract, will soon have another 54 million gallons of molasses under the new contract with the Cubans. What is Publicker going to do with all this molasses?

Some molasses, no doubt, will still go into production of ethyl alcohol. But with alcohol at 21c. a gal., a price which makes profit margins uncomfortably slim, Publicker may decide to divert part of its molasses to production of other solvents like acetone and butanol. With butanol, for example, selling at about 15c. a lb., compared with ethanol at about 3c. a lb., this would be a highly profitable operation right now.

Britain's chemical industry on the brink

Is Britain's chemical industry in danger of being nationalized? It has escaped; but it isn't safe.

Warning has been served by the Labor Government on Imperial Chemical Industries, Ltd., backbone of Britain's chemical industry. If the Labor Government detects monopolistic practices that operate against the public interest, down will come its nationalization club on ICI.

Vote-catching platform that soft-pedals nationalization of industries has been drafted by Labor Party strategists for next year's general election. Getting this platform through the Labor Party conference this June, however, is going to take some slick maneuvering by the moderates. Already, extreme left-wingers are clamoring for more nationalization.

Chemical industry is not overlooked in this Labor Party platform. Its importance to the British economy is compared with that of the already socialized coal and steel industries. Referring specifically to the chemical industry, the Labor platform declares that if necessary "to assure vital national industry, Labor will . . . transfer to public ownership any appropriate sections of this key industry."

What ails Jap chemical industry?

Japan's chemical industry, thinks Col. Frederick Pope, should be given a break. Pope, former president of Chemical Construction Co., has just surveyed the Japanese chemical industry. The highly controversial report he has submitted is a stinging criticism of U. S. occupation policy in Japan. What does Japan's chemical industry need most? Men and money, says Pope.

Men: Purging of top plant executives, declares Pope, has taken away the greatest asset the Japanese chemical industry had. Pope would give these purged men the right to work to help take Japan off the neck of the American taxpayer.

Money: Pope recommends loaning the Jap chemical companies money for five to 15 years at about 4½ percent interest. He thinks 95 to 98 percent of the loans would be repaid. And he is all for letting the Japanese charter American ships to transport salt.

Other steps urged by Pope: (1) stop removing chemical plants for reparations; (2) tear down the two Fischer-Tropsch plants in Japan; (3) re-examine limitations on output of potential war products to ease restrictions that cripple legitimate industries; (4) have the deconcentration board stop breaking up

(*Continued on page 70*)

Completely Automatic Control of Plant Processes...

LOWERS PRODUCTION COSTS
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BRISTOL'S SYSTEM OF COORDINATED PROCESS CONTROL— PIONEERED BY BRISTOL OVER 20 YEARS AGO PERFECTED THROUGH HUNDREDS OF SUCCESSFUL INSTALLATIONS

WHAT IT IS . . . Bristol's System of Coordinated Process Control culminates 60 years of precision instrument making. It is an engineered combination of automatic control instruments built in the form of a master control station. It controls, coordinates and interlocks all the vital variables in the processing cycle so that each takes place precisely *when* it should and *how* it should. A Bristol Cycle Controller acts as the "mechanical brain", coordinating all the other instruments. The system is shipped completely assembled, requiring only main power and air connections to put it to work in your plant.

WHAT IT DOES . . . Coordinated Control allows plant processing to conform to the exact plan which research and experience show produces optimum results. It times the operation of valves, pumps, blowers, dampers, switches, etc., and controls at predetermined values such variables as temperature, pressure, liquid level, flow, humidity, speed, pH, and vapor concentration. It eliminates variations in processing that cause inefficiency. It cuts down rejections and waste . . . insures product uniformity . . . quickly pays for itself.

WHY YOU SHOULD INVESTIGATE BRISTOL COORDINATED CONTROL . . . For every industrial process there is one set of conditions which produces the best results. These conditions can be achieved in the laboratory or pilot plant, but usually with difficulty in actual production. With Bristol Coordinated Control, the exact "formula", sequence of operations and degree of control necessary for maximum plant efficiency, product quality and uniformity can be transferred to the production stage with mathematical precision. The control system holds processing to the proper schedule and maintains the set conditions known to produce the best results . . . automatically. The apparatus is extremely flexible. Processing schedules are easily adapted to changing conditions.

NEW EFFICIENCY FOR A NEW ERA . . . With costs up all along the line, processing efficiency is more important than ever in securing competitive advantage. Bristol's Coordinated Process Control System is the most modern, most effective way to meet the challenge of rising costs . . . to secure new margins of profits . . . to open up new productive horizons. Each installation is separately engineered to the requirements of the process involved.

One example of its use is shown nearby. There are hundreds. Have us tell you more. THE BRISTOL COMPANY, 109 Bristol Road, Waterbury 91, Conn. (The Bristol Co. of Canada, Ltd., Toronto, Ont.; Bristol's Instrument Co., Ltd., Lynch Lane, Weymouth, Dorset, England.)

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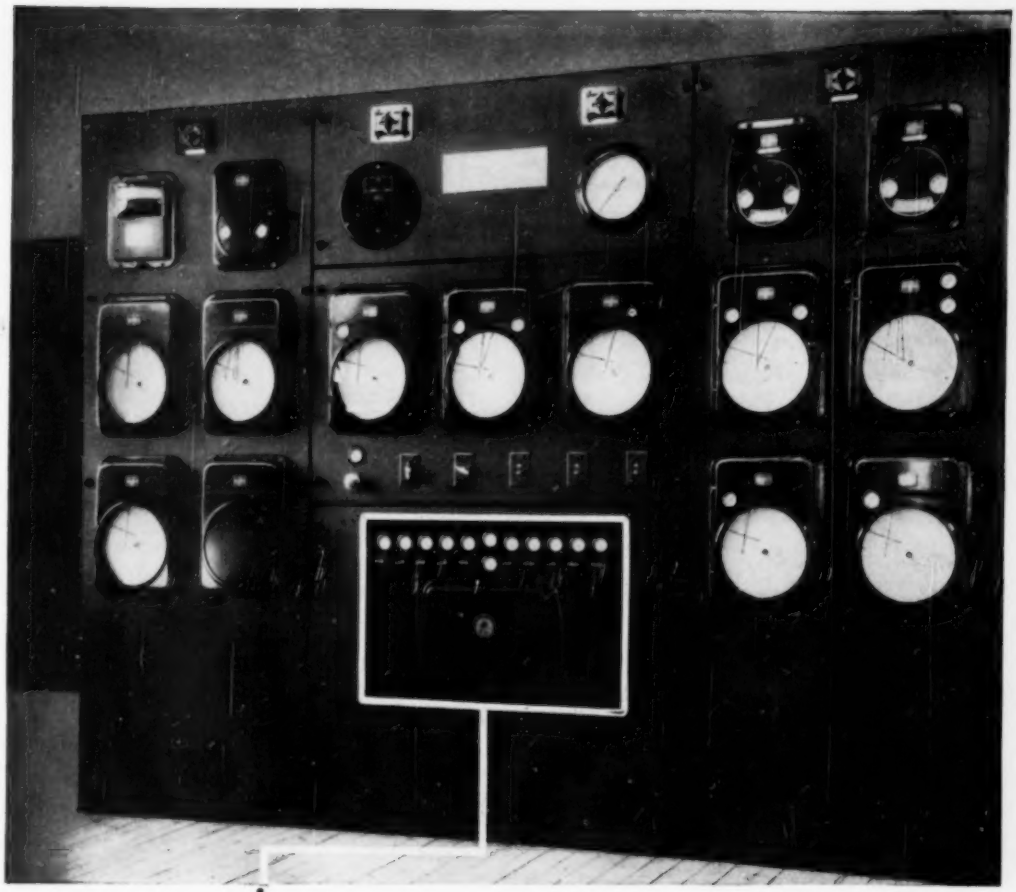

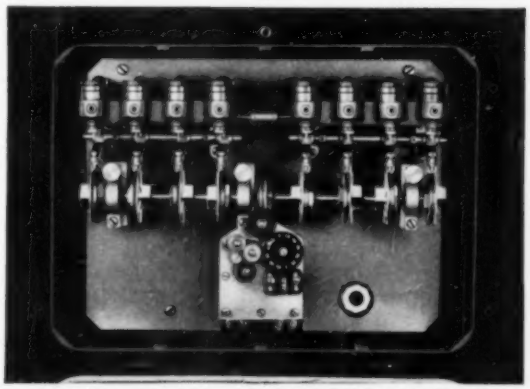

Bristol Process Cycle Controller, the "MECHANICAL BRAIN" of the above Coordinated Process Control System.

Above is a picture of a typical Bristol Coordinated Process Control System—completely automatic control of plant processes according to the schedule known to produce the desired results. Hundreds of these systems are in successful operation today. This modern technique of process control is being used by some of the most progressive and successful manufacturers in this country.

60 YEARS...1889-1949

BRISTOL

Coordinated Process Control

AND TELEMETERING INSTRUMENTS

all efficient organizations just because they are big; and (5) set up an executive engineering board on a temporary basis.

MacArthur, meantime, reminds that production of Japan's chemical industry is now 85.3 percent of the 1930-1934 level, against 20.4 percent when 1945 ended. And four more chemical companies have been absolved by the deconcentration board of excessive concentration of economic power since Pope drafted his report.

Dismantling of German chemical plants cut back

German chemical plants are not all to be torn down. At least, U. S., Britain and France have agreed to spare 32 of the 75 German chemical plants originally slated for dismantling.

Prohibited, until a peace treaty is signed, is German production of high explosives, nitrocellulose propellants, poison war gases and rocket fuel. Also forbidden is manufacture of primary magnesium and beryllium. Neither butadiene nor synthetic rubber can be made. Production of gasoline and oil lubricants from coal by the Bergius hydrogenation process or Fischer-Tropsch synthesis or by other processes is likewise out.

Ceilings have been clapped on production of other chemicals. Only 85,000 tons of primary aluminum a year can be turned out. Synthetic ammonia and chlorine can be produced only in plants remaining after the reparations removals. **Styrene** output is limited to 20,000 tons a year. Only the military governors can grant licenses lifting these ceilings.

Synthetics from Fischer-Tropsch plants will be prohibited after 1949. Once Germany has enough fats and oils to make soaps and cleansers, synthesis of hydrocarbon waxes and fatty acids will be discontinued. Meantime, some hydrocarbon waxes for synthetic fatty acids will come from Fischer-Tropsch plants and with them a trickle of synthetic fuels and lubricants.

Bergius plants, except the one at Wesseling, are to be removed or destroyed. The Wesseling plant will: (1) refine petroleum; (2) hydrogenate heavy refining residues; and (3) synthesize ammonia and methanol.

Agreement resulted from demands of ECA, backed by key Congressmen, that capital equipment be kept running in Western Germany to aid European recovery.

Government rubber still gummed up

Disposal of government rubber plants poses some tough problems. Preliminary report on disposal submitted by the Office of Rubber Reserve points this up.

Disagreement between Rubber Reserve and petrochemical and rubber industry advisory committees is manifest in the report. Recommendations of the industry groups are included in ORR's report to the President and Congress.

Rubber Reserve recommends that the government sell its rubber plants at prices reflecting "fair-value." This is based on cost of constructing comparable facilities. It assumes "highest and best" use of the government plants.

Rubber industry advisory committee recommends that the maximum sale price of the copolymer plants be no greater than 20 to 25 percent of what the government paid originally (average cost of a copolymer plant was $9 million).

Terms suggested by the rubber industry are 10 percent down, balance to be paid over 10 years. Government wants 20 percent down, with 10 annual payments on the balance.

Agreement of the rubber and petrochemical committees and ORR on one important point is complete: Congress is going to have to set a level of "assured usage" of synthetic rubber before disposal can go beyond the discussion stage.

Reason: fluctuations in price of natural rubber might knock synthetic out of the market unless the law—as it does now—compelled industry to use specified quantities of synthetic rubber. Only this guaranteed minimum market for synthetic will make purchase of the government plants attractive.

Red tape necessary if the government is to fix the assured usages of synthetic further complicates the disposal problem. Private industry shies away from investment in a new business beset not only by great economic risks but bogged down in government controls.

Spade work in ORR's report is all preliminary. Under the Rubber Act of 1948, President Truman has until next January to submit his recommendations on disposal.

Actual sale of the plants may not come until 1951. Meantime, here is how events are shaping up:

Congressmen will not be able to judge the President's plan when it reaches them—unless they do some homework on the rubber situation before the second session of the 80th Congress opens next January. At the moment, it looks unlikely that the House Armed Services Committee will undertake this study or visit the synthetic plants. So Congressmen will have to study the problem after Truman submits his disposal plan. And that means that they may not be able to decide on this controversial legislation by July 1950.

Result could be an extension of the present rubber law, which expires on June 30, 1950. This would give Congress time to pass and the President to approve a disposal law, with specific provisions included on assured usage of synthetic rubber.

(Continued on page 72)

The use of Formaldehyde to inhibit corrosion in oil wells is a fast growing economical practice today. Celanese® Formaldehyde, 25% by weight, has been found to be remarkably effective in inhibiting sulfide corrosion in wells when maintained in approximately 100 PPM in the brine produced. Field trials indicate this treatment decreases corrosion nearly 100 percent. It assures longer life to rods and tubing, and therefore less shutdown time.

Its great versatility, high order of chemical activity, low cost and ready availability place Formaldehyde high on the list of *probables* when new products and methods are studied.

To many in the chemical field, Formaldehyde means Celanese — one of the nation's largest producers, with production and shipping facilities geared to meet exacting requirements.

Special Celanese storage facilities in Corpus Christi, Texas, and New Haven, Connecticut, insure quality control and efficient service. In the Celanese Research Laboratories at Clarkwood, Texas, process improvements and new Formaldehyde products are under continual development.

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Labor-management fission

Davis Commission, as expected, did not recommend a ban on strikes in atomic energy plants or legislation to handle atomic labor disputes.

Recommendations of the commission, made to President Truman, stress voluntary no-strike-no-lockout procedures similar to those found in the railroad industry under the Railway Labor Act.

Plan, which Truman is taking "under consideration," calls for creation of a panel of three impartial members.

Panel would step into an atomic dispute after collective bargaining and conciliation had failed. If it could not bring about a settlement, it would make recommendations, but they would not be compulsory.

No strike or lockout would occur by agreement between AEC contractors and the unions until after the panel had issued its recommendations.

Paramount importance of the atomic energy industry is emphasized in the Davis Commission's findings. The "very special responsibility" of both labor and management in the atomic energy industry is recognized. And the point is made that vital operations "must not be interrupted by strikes or lockouts."

Wage negotiations with both CIO and AFL unions at Oak Ridge, where Carbide & Carbon is the AEC contractor, are coming to a head. In April, 250 electricians struck at the Hanford plutonium plant run by General Electric. And at Los Alamos, laborers walked off the job in a wage dispute.

Chemical unions forego boosts for benefits

Wage settlements follow no pattern in the chemical process industries. In chemicals, settlements have ranged all the way from 4c. to 15c. an hr., Bureau of Labor Statistics reports. A number of chemical companies have gotten by without any wage increase.

One of the biggest is Lever Bros. It recently signed new one-year contracts with the CIO and AFL chemical unions. There was no wage increase. Instead, Lever Bros. will pay group hospitalization for employees and their families. Also, paid holidays are increased from eight to nine a year.

Another is the W. C. Meredith Co. in Atlanta. Instead of a wage increase, it agreed with the CIO chemical union on an attendance bonus. Employees who are not tardy or absent for a week get bonuses of from 2½c. to 5c. an hr.

Social security benefits are a major factor in 1949 contract negotiations. Many unions are foregoing a wage increase—witness Lever Bros.—in return for sick benefits or pensions. Yet unions and employers are hesitating to make firm commitments until they know what Congress is going to do about expanding social security legislation.

Tentative arrangements are being made by some. Take E. F. Houghton & Co., Philadelphia manufacturer of industrial belting, oils, degreasers and solvents. It agreed with the CIO Oil Workers on a contributory group insurance plan. However, the contract includes this contingency: if Congress passes legislation granting either sickness or accident benefits, or both, to workers, either the company or the union may reopen the contract to seek a modification in the group insurance plan. Objective of any change would be to take into consideration the benefits provided by the government and the cost of those benefits to the company and the employees.

Du Pont's new Oxo process offspring

Long-chain alcohol is Du Pont's newest baby. And like many other recent arrivals, it was born of the Oxo synthesis. From diisobutylene, carbon monoxide and hydrogen, Du Pont makes an aldehyde. The aldehyde is hydrogenated to the new alcohol—trimethylhexanol.

Production at present is being carried out in a revamped unit at Du Pont's Belle, W. Va., works. High-pressure synthesis does the trick. And product purity is 98 percent or better. Already, trimethylhexanol at 28c. a lb. f.o.b. Belle is highballing to customers in tank cars.

Biggest use for the new higher alcohol will be in production of plasticizers. For this use, the alcohol is esterfied. Among the esters made are: sulphates, phosphates, adipates, maleates and phthalates. Reaction rates for esterifications are good; yields are high. Color of the crude esterification product equals that of most ester plasticizers after they have been treated with activated carbon.

Other uses for Du Pont's new Oxo offspring are in surface active agents, lubricating oil additives and specialty printing inks.

Ohio, mother of chemical enterprises

Ohio is attracting more chemical process industries all the time.

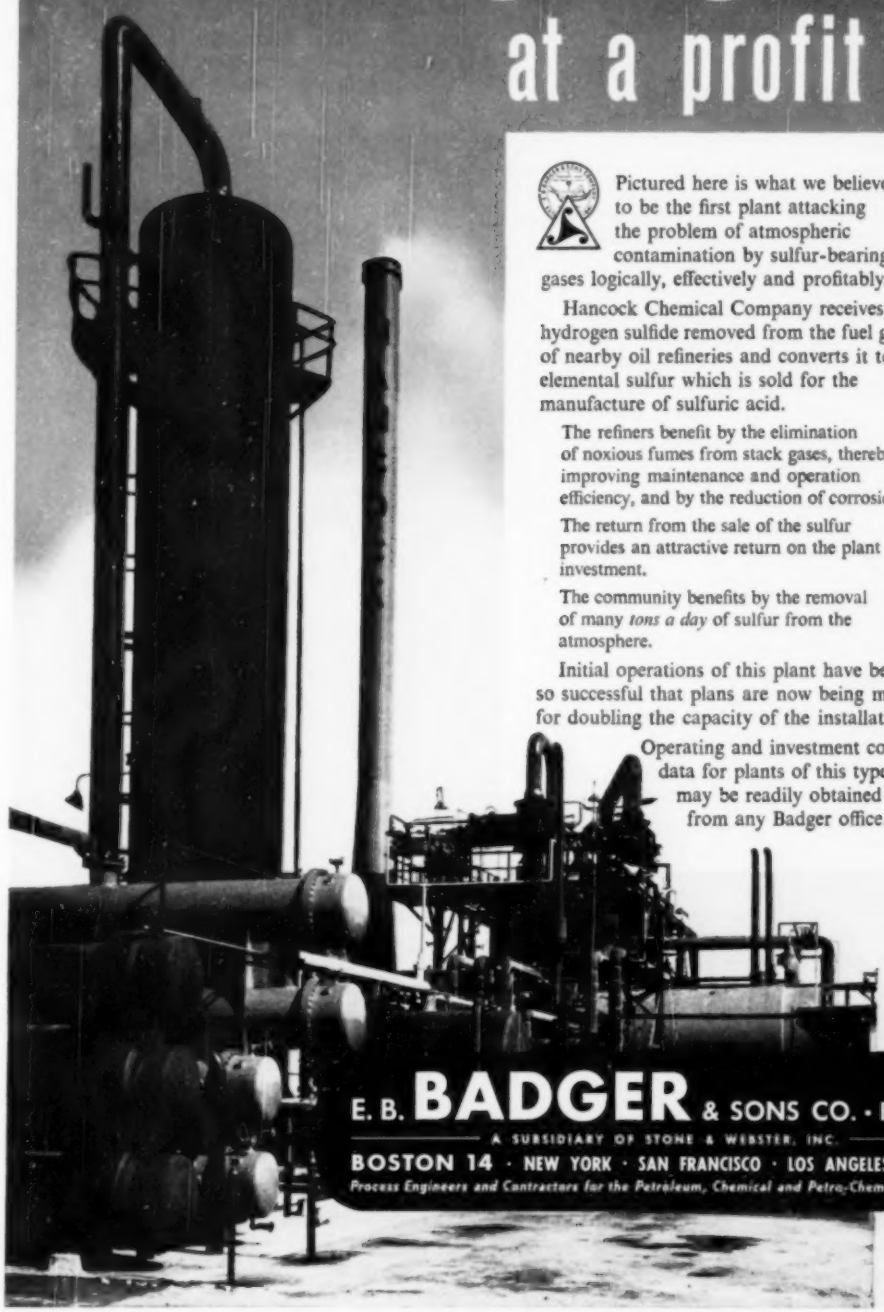
Ironton may become the site of a Dow plant. Dow has renewed its option on a 400-acre tract there until November to give its engineers more time to study the possibilities of the location. Dow is mum on what kind of a plant it might put up.

Marietta is another place that is getting close attention. Union Carbide's Bakelite Corp. hopes to be turning out phenol from chlorobenzene in a new plant just south of Marietta in the Ohio River valley by 1950.

Grapevine is over-ripe with other rumors about Marietta. U. S. Rubber executives and engineers are supposed to have picked a plant site there. Timken Roller Bearing is said to have options on land in the Belpre area at Marietta. This ties in with

(*Continued on page 74*)

eliminating smog at a profit



Pictured here is what we believe to be the first plant attacking the problem of atmospheric contamination by sulfur-bearing gases logically, effectively and profitably.

Hancock Chemical Company receives hydrogen sulfide removed from the fuel gases of nearby oil refineries and converts it to elemental sulfur which is sold for the manufacture of sulfuric acid.

The refiners benefit by the elimination of noxious fumes from stack gases, thereby improving maintenance and operation efficiency, and by the reduction of corrosion.

The return from the sale of the sulfur provides an attractive return on the plant investment.

The community benefits by the removal of many *tons a day* of sulfur from the atmosphere.

Initial operations of this plant have been so successful that plans are now being made for doubling the capacity of the installation.

Operating and investment cost data for plants of this type may be readily obtained from any Badger office.

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rumors of an alloy steel plant to be built between Belpre and Marietta by Union Carbide. The Carbide plant would furnish alloy steels for the Timken operation.

Sodium catalyzes Ashtabula activity

Sodium metal, sodium hydride and chlorine will soon be coming from the new $10 million plant that National Distillers Chemical is building at Ashtabula, Ohio. Byproducts from this operation are luring still other chemical companies to Ashtabula.

New plant at Ashtabula will be built by Hooker-Detrex to process further byproducts from National Distillers Chemical. Deal has been completed whereby Detrex Corp. of Detroit and Hooker Electrochemical form this new company, Hooker-Detrex. Land has been purchased for Hooker-Detrex.

New board chairman of National Distillers Chemical is Francis B. Davis, Jr., former board chairman of U. S. Rubber.

Bargain-counter oxygen

Low-cost oxygen from air is now being produced commercially by a process developed by Hydrocarbon Research. The plant, first of its kind, is that of McCarthy Chemical at Winnie, Tex.

Production exceeds 200 gross tons of 90 percent oxygen a day. McCarthy Chemical uses it for synthesis of methanol, formaldehyde and other petrochemicals.

Bargain price of $3.50 a ton is possible when oxygen is made in large quantities by this process for such industrial uses as steel making, synthetic fuels production and other chemical processes. Cost at McCarthy Chemical, however, is somewhat higher than that right now.

Industrial utility just like steam and electricity is what oxygen becomes at $3.50 a ton.

Second plant using the Hydrocarbon Research process will be running later this year. Being built for Carthage Hydrocol at Brownsville, Tex., it will turn out 2,000 tons of oxygen a day. While the plant at Winnie, Tex., is now the world's largest single commercial installation, it will be dwarfed by this second plant.

Goliath of the high-vacuum stills

Goodrich Chemical plans to install a unique high-vacuum still. It will be the largest ever made.

A falling-film still, it will be built by the National Research Corp. The still will operate at a total pressure of about 1 micron. It will have a throughput of 1½ tons an hour.

Plasticizer production is the job for which this big high-vacuum still is being built. It will be used in improving color and removing impurities.

Bigger and better phosphate furnaces

Capacity for the production of phosphate in electric furnaces has been greatly expanded since the end of the war. In both Tennessee and Florida added capacity has been installed. And in the West a furnace plant is under construction.

A revolving hearth is the feature of a phosphate furnace that TVA is experimenting with. In Europe furnaces for silicon and ferrosilicon have revolving hearths. For further development work, TVA will probably build a larger revolving-hearth furnace.

Biggest problem besetting future expansion: how to get enough power at reasonable rates.

Record production ends six-year pulp shortage

Wood pulp consumed in the U. S. in 1948 reached a record-shattering 15 million tons, of which 13 million tons were produced in U. S. mills and 2 million tons were imported. Thus ended a six-year pulp shortage which had hamstrung business and industry.

U. S. pulp mills produced 12,864,000 tons, a gain of 918,000 tons over 1947 output. Of this record production, 10,738,000 tons were chemical pulps, up 842,000 tons over 1947. Last year a total of 2,126,000 tons of mechanical pulp for newsprint and other uses were produced, an increase over 1947 of 76,000 tons.

Imports to U. S. of wood pulp during 1948 fell 154,000 tons below 1947. They totaled 2,176,000 tons last year.

Exports from U. S. had little impact on the U. S. supply situation. They took only 96,000 tons of the record 1948 production, 21,000 tons less than in 1947.

Long-term trend in wood-pulp production is a steadily climbing one. The new supply of 14,944,000 tons in 1948 compares with 14,159,000 tons in 1947, 6,690,000 tons in 1929 and 1,216,000 tons in 1899.

Pulp and related industries grow faster than population or industry as a whole, due to new uses and new applications for the product. Per capita consumption of paper, principal end product of pulp, rose in the U. S. from 57 lb. in 1899 to 220 lb. in 1929 and to 343 lb. in 1947.

This year, whether or not another new record is set, will be a good year for the pulp industry. And for the long pull, the industry's historic growth points to increased consumption of pulp and paper.

A $5 million market?

When the Maritime Commission decided to mothball 2,000 ships of its merchant fleet just in case, it sought a preservative for hull bottoms.

Vinyl-resin coatings, which will resist corrosion and underwater growths for six or seven years, turned the trick. The Commission estimates that it will need more than 800,000 gal. of these vinyl coatings during the projected 20-yr. life of the reserve fleet. At a current cost of $7 a gal., this would come to more than $5.6 million. —*End*

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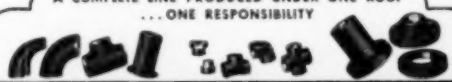

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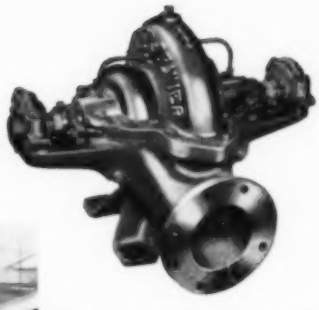
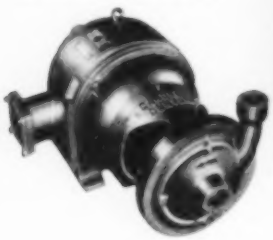
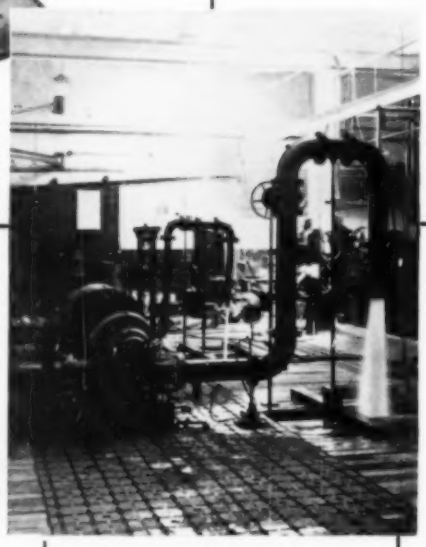
FOR HANDLING FLUIDS CONTAINING SOLIDS up to 6 inches in diameter, Gardner-Denver Sewage and Waste Disposal Pumps are built in capacities from 50 to 5000 gallons per minute.



RUGGEDLY CONSTRUCTED FOR LARGE CAPACITY Gardner-Denver Horizontally Split Case Double Suction Centrifugals are available in sizes for all heads up to 300 feet.

COMPACT Gardner-Denver Close-Coupled Centrifugal Pumps may be installed in any horizontal or vertical position—are designed for capacities up to 250 gallons per minute and heads up to 250 feet.





Gardner-Denver's modern hydraulic testing laboratory, showing centrifugal pump direct connected to Dynamometer for efficiency test.

FOR GENERAL UTILITY SERVICE Gardner-Denver Side-Suction Centrifugal Pumps are made in capacities up to 1600 gallons per minute and heads up to 100 feet.

Fully Tested

For Full-Value Efficiency Gardner-Denver Centrifugal Pumps

Since 1859

You can be sure of getting *full-value* efficiency on every one of your pumping jobs when you insist on Gardner-Denver *fully tested* Centrifugal Pumps. For every Gardner-Denver pump you buy has already proved its dependability and power economy — through thorough and accurate testing in our modern hydraulic laboratory, completely equipped with the best and most accurate testing equipment available. It's no wonder these popular pumps so easily attain and often exceed their rated efficiencies in hundreds of different kinds of pumping installations.

For expert advice on selecting just the right Gardner-Denver Centrifugal for any installation, or for further information on any of the pumps described here, write Gardner-Denver Company, Quincy, Illinois.

GARDNER-DENVER

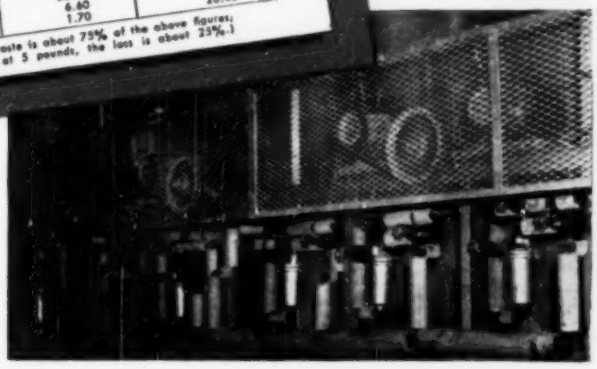
SMALL STEAM LEAKS *add up!*

Showing cost of various sized steam leaks at 100 pound pressure. (Assuming steam costs 50 cents per 1000 lbs.)

Size of Orifice	Lb. Steam Wasted Per Month	Total Cost Per Month	Total Cost Per Year
1/2"	835,000	$417.50	$5,010.00
3/8"	470,000	235.00	2,820.00
1/4"	210,000	105.00	1,260.00
1/8"	52,500	26.25	315.00
1/16"	13,200	6.60	79.20
1/32"	3,400	1.70	20.40

(For steam at 50 pounds pressure, the waste is about 75% of the above figures; at 20 pounds, it is about 50%; and at 5 pounds, the loss is about 25%.)

SEE OUR CATALOG IN SWEET'S



TYPICAL FUEL SAVINGS SECURED WITH ARMSTRONG TRAPS

20% FUEL SAVINGS after trapping all heating coils individually. — Norton Greenhouses, St. Paul, Minn.

33-1/3% REDUCTION IN ANNUAL COAL BILL after installing Armstrong traps on cooking vats. — Ralph L. Smith Lumber Co., North Kansas City, Mo.

3,728 GALLONS OF FUEL OIL SAVED in one year after replacing old traps with Armstrongs on kettles, low pressure heating system and cream beaters. — Mary Lincoln Candies, Buffalo, N. Y.

STEAM SAVERS:

For trapping heating systems and process equipment from 1 to 250 psi, Armstrong Traps are available in side inlet—side outlet or bottom inlet—top outlet body styles. These compact, dependable traps provide more actual hot condensate capacity per dollar of trap investment than any other traps on the market. For selection data, capacities and prices SEND FOR the 36-page ARMSTRONG STEAM TRAP BOOK.

CHECK YOUR STEAM TRAPS *now!*

The chart above shows that a "little" steam leak can cost a lot—and a hundred or a thousand little leaks cost a lot more! No plant can afford the luxury of leaky steam traps. It costs far more to keep them than it does to replace them with modern Armstrong Inverted Bucket Steam Traps. Armstrong Traps won't leak steam because:

1. The valve and seat are ground and lapped to a precision, steam-tight fit.
2. The valve is water-sealed at all times.
3. Both the valve and seat are made of chrome steel, heat treated for long life and corrosion and erosion resistance.

With today's high fuel and operating costs Armstrong traps are priced lower in proportion to the savings they can effect than at any time in their history. Let your nearby Armstrong Representative help you select the traps you need or write direct to the factory.

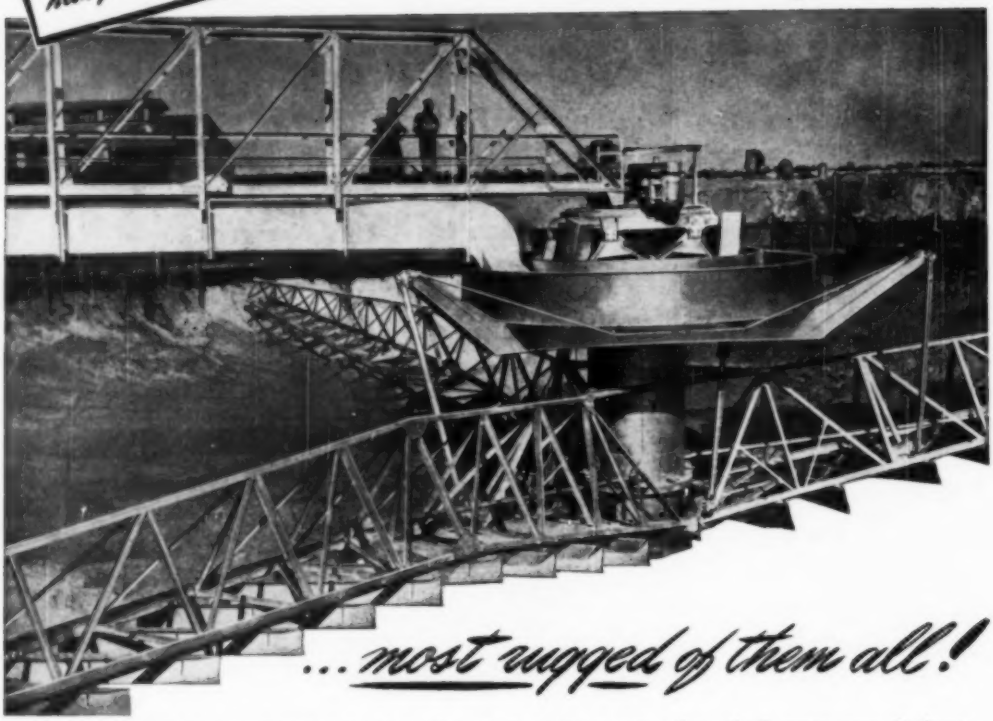
ARMSTRONG MACHINE WORKS
858 MAPLE ST., THREE RIVERS, MICH.

ARMSTRONG *Inverted Bucket* STEAM TRAPS

Factory Representatives in 48 Key Cities... Traps Stocked at 147 Points

What's NEW... in heavy duty equipment?

The Dorr Type PL Parallel Lift Hydroseparator



... most rugged of them all!

Sweeping statement? Perhaps . . . but look at these facts and see why the new Dorr Type PL tops them all for heavy duty operation.

PL MEANS PARALLEL LIFT OF RAKES IN CASE OF OVERLOAD . . . As overload is encountered, torque causes entire raking mechanism to raise with rakes parallel to tank bottom . . . no matter where point of load occurs.

HYDRAULIC LIFT . . . In case of shut-down, a powerful hydraulic lifting device will raise raking mechanism up to 2 feet off tank floor. Parallel and hydraulic lifts are integrally designed . . . with hydraulic lift cylinders acting as shock absorbers in case of sudden torque loads and eliminating sudden drop of raking mechanism.

POWER PLUS IN DRIVE . . . Drive unit is low center of gravity, balanced spur gear drive delivering 800,000 foot pounds torque. Twice as powerful as any drivehead yet developed for similar duty!

TRIANGULAR CONSTRUCTION THROUGHOUT . . . Three rake arms . . . of triangular truss construction. All Type PL structural members form triangles for maximum rigidity and strength.

"Non plug" center cone discharge, kept open by a special "tickler" scraper . . . simple, single turntable design . . . both add to the ability of the Type PL to handle the heaviest loads without balking.

Where units of 100' diameter and larger are required in phosphate rock, sand, coal or any field where the going is really tough . . . the Dorr Type PL is the answer. A Dorr engineer will gladly give you more detailed facts on this new development.

DORRCO

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Dorr Technical Services and Equipment Are Also Available Through Associated Companies and Representatives in the Principal Cities of the World. Names and Addresses on Request.

RESEARCH — ENGINEERING — EQUIPMENT

DORR

aluminum protects . . .

PROTECTS NAVAL STORES FROM CUP TO CONSUMER

Struthers-Wells High-Velocity Vertical Evaporator of Alcoa Aluminum—for high production of rosin-naphtha solutions without contamination.

Alcoa Aluminum eliminates color pickup and contamination for many chemical processes. In naval stores and their derivatives, for example, you save when you collect in aluminum gum cups, process in aluminum equipment, ship in aluminum containers.

Alcoa's Development Division will show you research results, operating records and fabrication information...facts about aluminum equipment to help you plan and increase the dollar output of your distilling plants. Ask your nearby Alcoa sales office, or write ALUMINUM COMPANY OF AMERICA, 2151 Gulf Building, Pittsburgh 19, Pa.

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ALCOA ALUMINUM

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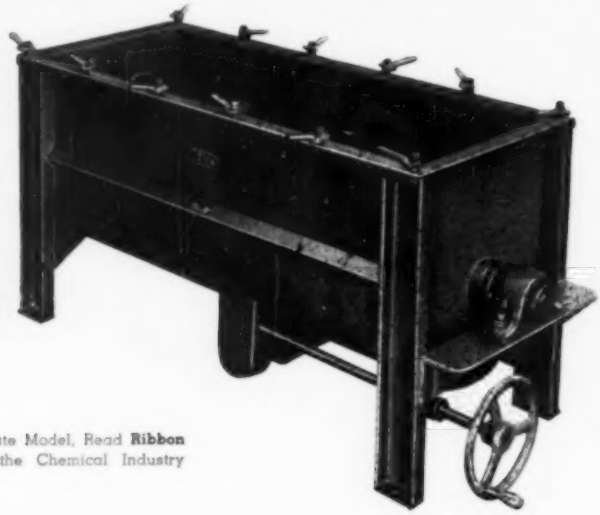
Read the Facts about READ Chemical Equipment



Flush Plug Gate Model, Read **Ribbon Blenders** for the Chemical Industry

FLUSH PLUG DISCHARGE

means no dead material at any time

IN BLENDERS, the elimination of dead material at the discharge point, plus the liquid-type flush plug discharge gate, assure you of efficient blending on a minimum operating cycle. Their rugged construction means longer life.

READ Ribbon Blender Advantages:

- Gate control handle placed either end, either side, or top to suit your needs.
- Gate is operated by self-locking worm and worm wheel.
- Blend any dry granular material; any moist or light mass material.
- Counter-flow action to insure rapid, efficient mixing without material build-up at the ends. Agitator removed by slotted end or coupling.
- Offered in batch capacities of from 1 to 500 cu. ft. Special units are custom-built for larger capacities.
- Models can be supplied for operation under pressure or full vacuum; can be equipped with temperature controlling jackets, to suit the application. Legs supplied in various heights to suit operating conditions.

BRING YOUR BLENDING PROBLEMS TO READ

WHAT'S YOUR NEED?

CALL ON. . .

MAKERS OF READCO CHEMICAL EQUIPMENT

READ MACHINERY DIVISION

of THE STANDARD STOKER COMPANY, INC.
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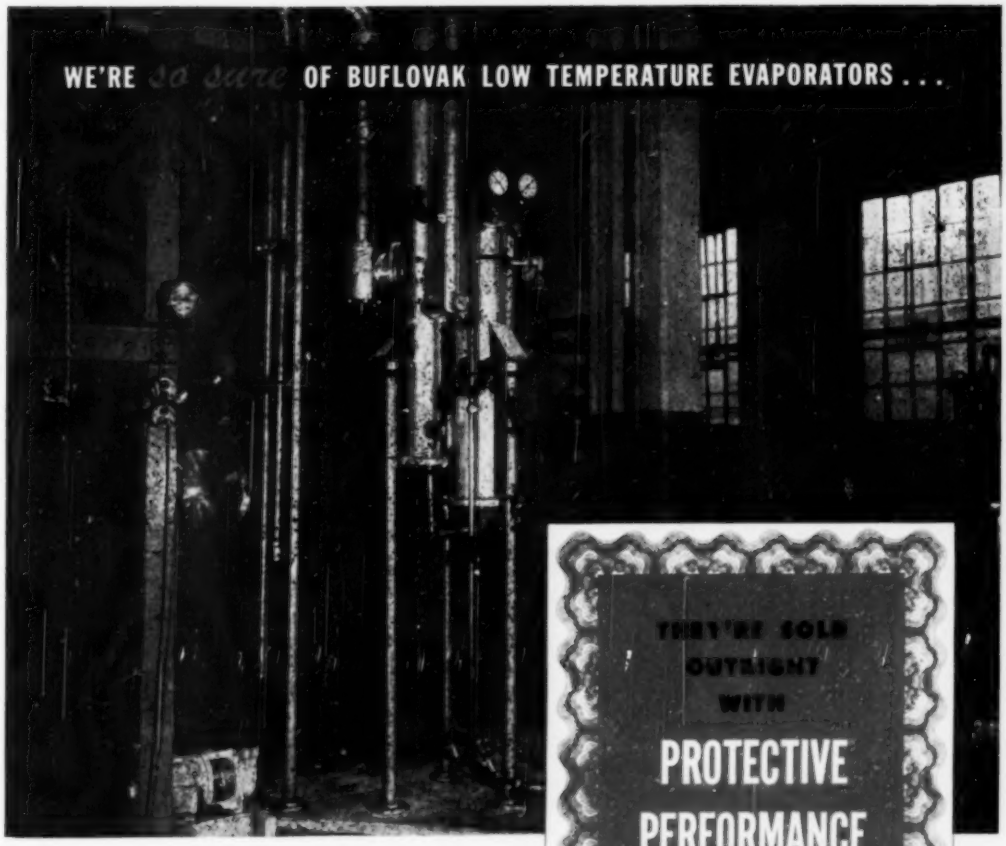
Write for literature and specifications on **Read Blenders.**

WE'RE *so sure* OF BUFLOVAK LOW TEMPERATURE EVAPORATORS . . .



THEY'RE SOLD OUTRIGHT WITH

PROTECTIVE PERFORMANCE GUARANTEES!

Here's *why* we issue "Protective Performance Guarantees" with Buflovak Low Temperature Evaporators. We know their quality . . . and we know they protect the quality of the most delicate materials!

Thus, you get *safe treatment* for many Food or Chemical products.

Buflovak's Low Temperature Evaporator operates at extremely low temperatures and pressures. Day after day you are assured dependable operations, with long operating periods. Automatic controls simplify operation, save labor, and give uniform results, even to the density of the product.

Buflovak Equipment *always* gives high product quality at low production cost.

Write today for full information on these Low Temperature Evaporators or Buflovak Equipment for processing Chemicals and Foods, DRYERS, SOLVENT RECOVERY and PROCESSING EQUIPMENT.

BUFLOVAK EQUIPMENT

Division of Blaw-Knox Co.

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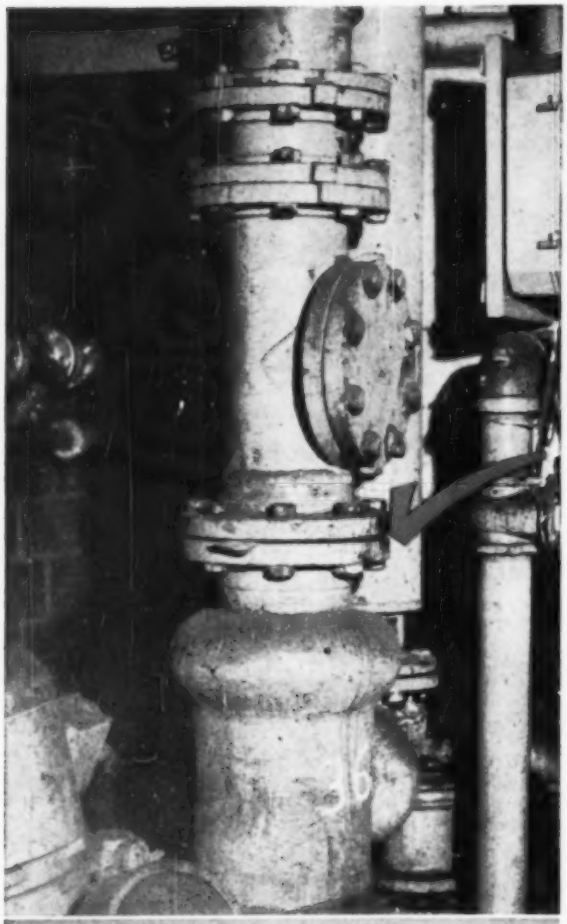
To The Chemical Industry:

PLAY SAFE with



BS&B SAFETY HEADS

Black, Sivalls & Bryson SAFETY HEADS offer the chemical industry unfailing protection against *over*-pressure "bursting point" danger. To our knowledge, *no vessel protected by a SAFETY HEAD has ever blown up!*

The BS&B SAFETY HEAD is a simple, easily installed metal rupture disc, held between specially designed base and hold-down flanges. It positively bursts at predetermined pressure. More than 100,000 of these discs have been burst in the BS&B laboratories to assure absolute precision in *over*-pressure control.

Don't let another day go by without seeing to this basic protection for life and property!

Write or call Special Products Division, Dept. SH-5, Block, Sivalls & Bryson, Inc., Power and Light Bldg., Kansas City 6, Mo.

BS&B SAFETY HEADS

Special Products Div., Dept. SH-5, Block, Sivalls & Bryson, Inc., Power & Light Bldg., Kansas City 6, Missouri

I'd like full details of the BS&B Safety Heads.

☐ Please forward complete data.
☐ Arrange to have Sales Engineer call on me.

Name _____

Firm _____

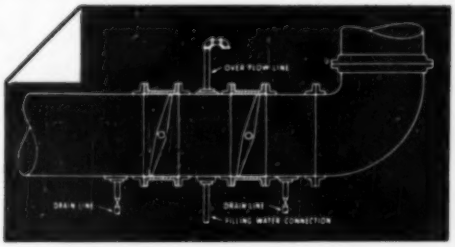
Address _____

City _____ State _____

R-S valvEvents

• EXCERPTS FROM THE R-S BOOK OF EXPERIENCE •

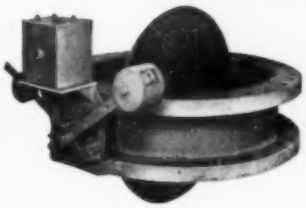
How to Seal a Gas Line



The sealing of gas lines is required in many plants as a protective measure. It is advantageous to adapt the method sketched above because of its low cost, positive seal and the fact that it requires minimum space in the line.

When the gas is to be shut off, the two R-S Valves are closed and the space between filled with water or other material, thus forming a tight seal.

Immediate Shut-Off or Vent



No. 628. Should solenoid operator function, the R-S Valve installed in a line either closes or opens immediately.

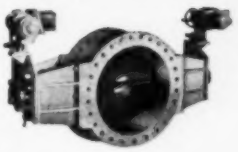
The R-S Solenoid Trip Valve is used for emergency service. The solenoid can be arranged with the counterweight mechanism to open or close the valve and hold it there in one position or the other. If for any reason the solenoid functions, the latch is tripped, which permits the counterweight to open or close the valve by gravity. The assembly is suited to shut off the flow or to open a vent and requires manual reset. Can be constructed of any metal or alloy and in various sizes for air, gases, steam, oil, water and other services. Types 649 and 696 are spring loaded (spring utilized instead of counterweight). Very popular for marine service.

Write for catalog No. 17 or consult with the R-S representative in your locality. You will find the address and phone number listed under "R-S Products Corporation, Valves."

R-S Products Corporation, Wayne Junction, Philadelphia 44, Pa.

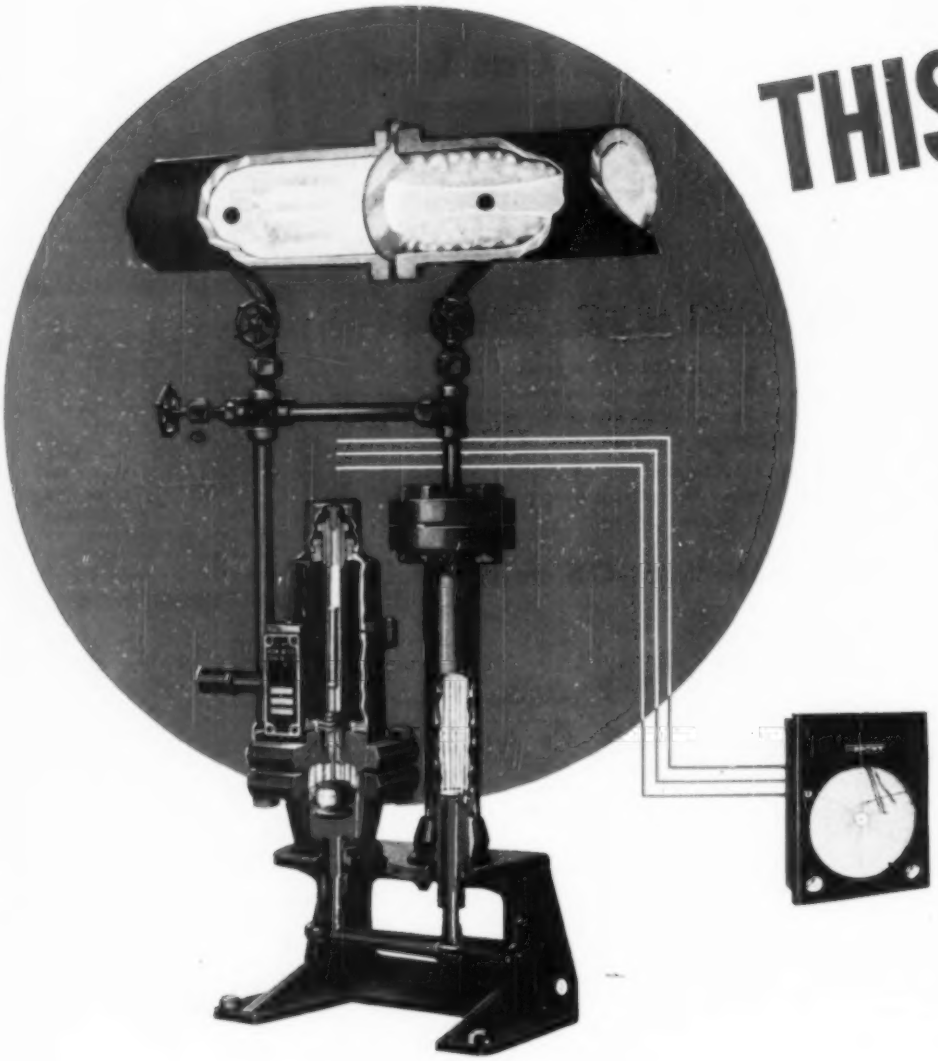
No. 728. 54-inch 50-pound Iron Valve for water service. Extremely rugged construction. Limitorque electric motor drive with threaded reach rod moves valve very slowly to prevent water hammer.

No. 722. 16-inch 125-pound Cast Iron Valve equipped with rubber spool for positive shut-off. Air Cylinder operated. Position of valve vane indicated by operating lights.



No. 725. 36-inch by 8-inch 150-pound Class B Alloy Steel Dual Valve. Controls high pressure drop and small volume or low pressure drop and large volume.

No. 719. 12-inch Steel Angle Slide Valve with 300-pound American Standard raised face flanges. Air cylinder and rising stem hand wheel operator with declutching unit. Controls liquids, gases and solids including catalysts.


THIS

FLOW METER DOES IT

gives you the benefits of Proved Performance with Minimum Maintenance plus Close Coupling

YES *proved performance through continuous acceptance for years in thousands of installations.*

YES *minimum maintenance because it is easily cleaned and calibrated.*

YES *close coupling because the meter body can be mounted right at the point of measurement.*

You can have close coupling to the point of flow measurement with close control of fluid flow from a remote location. Control may be obtained through any of four pneumatically operated systems . . . control as precise, as accurate, as close as the process justifies.

Maintenance is extremely low . . . range tubes are interchangeable and can be cleaned in a matter of minutes.

For close coupling to the line and close control of fluid flow, your best bet is the Brown Electric Flow Meter. Call in your local Brown engineer for free consultation and advice, today . . . he is as near to you as your phone.

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TRANS

...with

Taylor's new force-balance temperature transmitter is faster, needs little maintenance, has a tiny bulb and short, shiftable range spans

HERE is a new kind of instrument that pneumatically transmits temperature as far as 1000 feet—with an extremely high degree of accuracy! Thermal element gives 63% response in less than 2 seconds (agitated water).

In addition, Speed-Act,—an entirely new technique in temperature measurement—may be added to compensate for unusual thermal lags such as occur in applications requiring separable wells.

COMPARE TRANSAIRE'S* 9 OUTSTANDING FEATURES:

1. Faster—Unprecedented speed of response.

2. Tiny, "cigarette size" bulb is more adaptable to confined space, contributes to fast speed of response. $\frac{3}{8}$" by 3" or $\frac{1}{2}$" by $3\frac{7}{16}$".

3. Short, shiftable range spans:

(a) Standard range span of 50° available where you need exceptionally close readings. Other operating range spans: 100°, 200 and 400°F.; or 25°, 50°, 100° and 200°C. Overall temperature limits from minus 375° to plus 1000°F. or minus 200°C to plus 500°C.

(b) You can shift 50° span with screwdriver from 0 to 50° to 50° to 100°, or 100° to 150°, or any intermediate 50°F. interval. Other spans similarly adjusted.

(c) Range limits interchangeable by substitution of new spring assembly, giving much greater flexibility.

4. Little or no maintenance needed. Force-balance principle practically eliminates wear. Instrument may be quickly adapted to different operating conditions by interchangeable thermal system, spring assemblies and manifold. Permits low inventory of components.

5. Eliminates all electrical hazards in explosive atmospheres.

6. Positive-acting Pilot Valve—Taylor FULSCOPE Relay Air Valve assures quick changes in transmission pressure, overcomes effect of minor leaks.

7. Fixed and Linear Output Range—3 to 15 psi output for full temperature span is linear to 0.012 psi. Fixed output pressure span *eliminates need for individual calibration of receivers or receiver-controllers.*

8. Fully Compensated for barometric and ambient temperature changes.

9. Great Overrange Protection—withstands temperatures of 1000°F. regardless of range.

TRANSAIRE* with SPEED-ACT is one more step in Taylor's coordinated program for developing better industrial instrumentation. It grew from intensive research and design effort which had just one purpose: to produce a temperature transmitter *unsurpassed in accuracy and durability.*

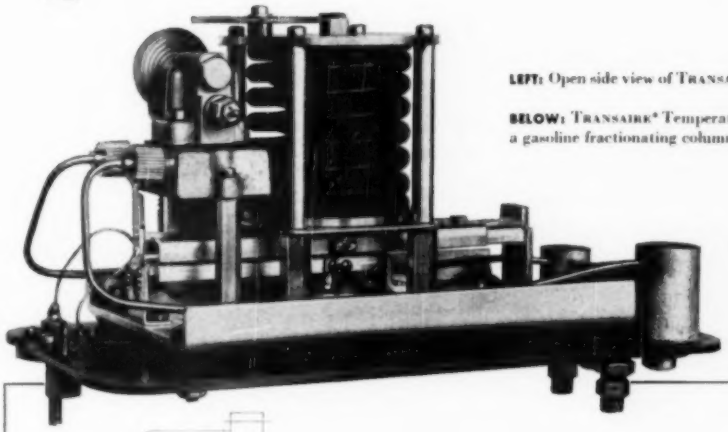
Ask your Taylor Field Engineer! Or write for **Bulletin 98140.** Taylor Instrument Companies, Rochester, N. Y., or Toronto, Canada.

• • •

Instruments for indicating, recording and controlling temperature, pressure, humidity, flow and liquid level.

AIRE* !

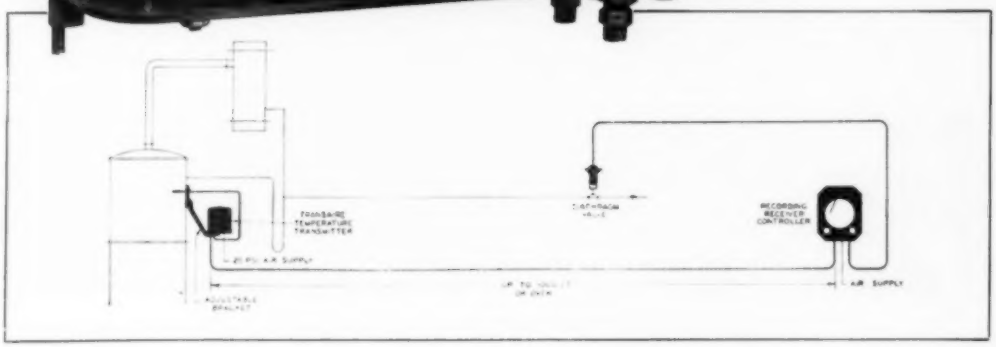
Speed-Act!



LEFT: Open side view of TRANSAIRE* Temperature Transmitter.

BELOW: TRANSAIRE* Temperature Transmitter in operation on a gasoline fractionating column.

* Trade-Mark



QUICK PICTURE OF FORCE BALANCE

TRANSAIRE* consists of *four* main assemblies:

1. A unique gas thermal system which provides force necessary to actuate transmitter.

2. A simple lever which transmits the force of the thermal system to operate the baffle—no pivots used!

3. A spring and compensating bellows assembly which balances the initial pressure in thermal system and compensates for barometric and temperature changes.

4. A balancing pneumatic circuit consisting of a bellows, baffle, nozzle and relay valve. These convert force developed by lever to precisely proportion output air pressure according to measured temperature.

Taylor Instruments

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With Atlas Acid-proof Construction

ATLAS **MATERIALS OF CHEMICAL CONSTRUCTION INCLUDE**

SIX LINING MATERIALS for steel and concrete: Atlastiseal, Carbo-Atlastiseal, Atlastic No. 37, Rewbon, Neobon and Zerok.

SIX CORROSION-RESISTING CEMENTS: Tegul-Vitrobond, Carbo-Vitrobond, Korez, Carbo-Korez, Alkor and Vitrex.

PROTECTIVE COATINGS for brush and spray application.

ATLAS **PATENTED CONSTRUCTION:** Interlocking Expansion Joints, Dual Construction.

ATLAS **SERVICE** includes design, material recommendations to meet specific operating conditions in all types of chemical tanks, acid and alkali-proof floors, sewers, stacks and fume ducts: and when desired, EXPERIENCED SUPERVISION furnished for your construction.

ATLAS maintains an effective *RESEARCH ORGANIZATION* at the disposal of our clients at all times, without obligation.

ATLAS **INSTALLATIONS** mean DURABLE CONSTRUCTION, resulting in LOW MAINTENANCE COSTS, and minimum loss in production due to shut-downs for repairs.

ATLAS DUAL CONSTRUCTION: **Rubber lined steel tanks with 8" two course Dual Construction, Alkor and Tegul-Vitrobond jointed Atlas brick sheathing, equipped with Atlas Interlocking Expansion Joints, Zerok Coating outside of tanks for fume protection. Service condition: 15% H_2SO_4, temperatures to boiling point.**

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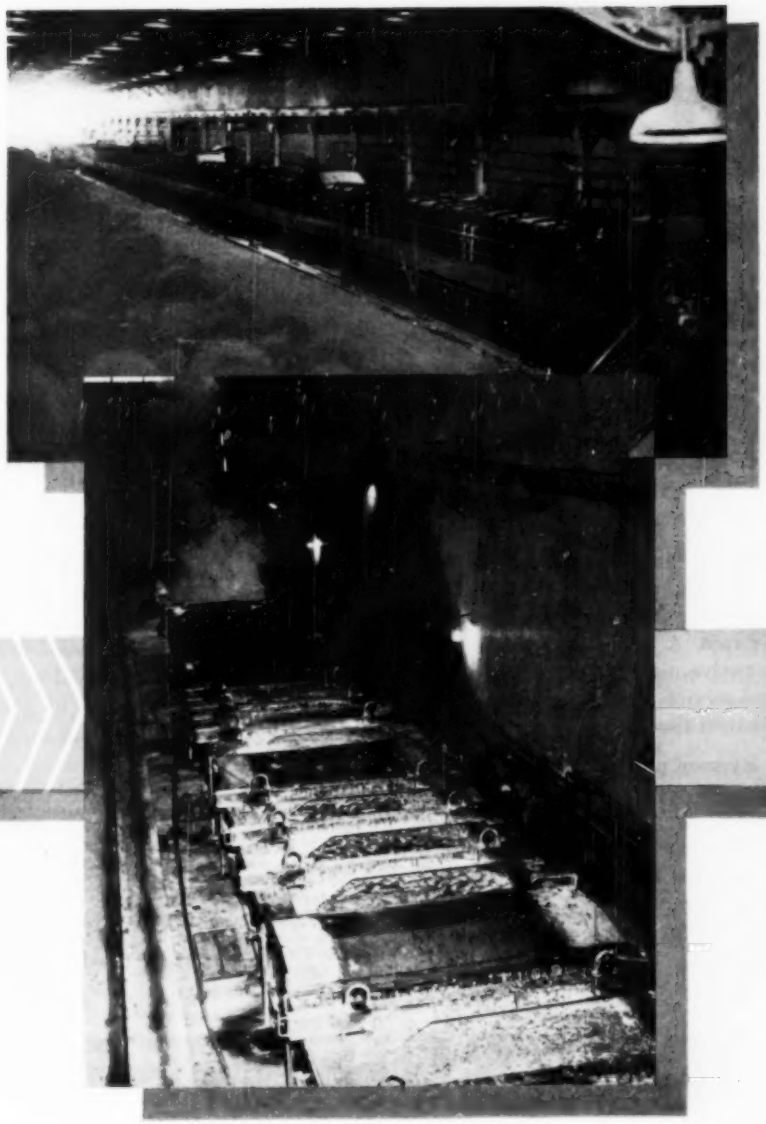
CORROSIVE SOLUTIONS AND FUMES
CEASE TO BE A PROBLEM!



Close to You Anywhere, Ryerson Stocks—Ryerson Service

No matter where you are, or where you want steel delivered, there's a Ryerson plant, with diversified Ryerson steel stocks, within quick shipping distance. A network of thirteen big plants, plus twelve district sales offices, makes Ryerson steel service the most comprehensive and convenient in the nation.

Each big Ryerson plant is set up to operate independently with large stocks and high-speed cutting and handling facilities, plus its own complete staff of carbon, alloy and stainless steel specialists. Yet each Ryerson plant and office offers the advantages of a unified organization with a hundred and six years of practical steel experience.

These days, with the record-breaking demand for steel, we may not always have the exact size or quantity you need. But you can be sure we will do our very best to serve you. Usually, from long experience, we are able to suggest an available alternate steel. So, for steel and steel service, call the Ryerson plant or office nearest you.

Need Stainless? . . . Call Ryerson

Your nearby Ryerson plant is a quick, convenient source for everything in stainless steel. Bars, plates, sheets, tubing, pipe and other stainless products in many types and finishes are on hand. And stainless from Ryerson stocks means Allegheny stainless, the time-tested product of America's oldest stainless producer. Need stainless? Call Ryerson.

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JOSEPH T. RYERSON & SON, INC. PLANTS: NEW YORK, BOSTON, PHILADELPHIA, DETROIT, CINCINNATI, CLEVELAND, PITTSBURGH, BUFFALO, CHICAGO, MILWAUKEE, ST. LOUIS, LOS ANGELES, SAN FRANCISCO

ESTABLISHED 1902 SIDNEY D. KIRKPATRICK, Editor

Chemical Engineering

WITH CHEMICAL & METALLURGICAL ENGINEERING

MAY 1949

Starting a Second Cycle

With this issue, our annual series of unit operations studies begins its second cycle. Again the editorial theme is Fluid Flow, just as it was back in May 1937. In the intervening years this field has grown faster than most of us realize. There are today many more specialists than there were then and vastly more literature, both periodical and permanent.

World War II tremendously accelerated the study of fluid dynamics and brought with it many practical developments in pumps and compressors, and in the techniques of high vacuum and the handling of fluidized solids. Similar advances were made in hydrodynamics and aerodynamics, which on the surface, might seem to hold little interest for chemical engineers.

So our current study has as its main objective to deal with this newer work in fluid dynamics and to show what it means from the practical viewpoint of the non-specialist engineer in industry. Theory and practice are further tied together in a unique article that offers a means of visualizing common flow problems and simplifies both their accurate calculation and their rapid estimation. And rounding out the whole report is a series of short articles to show not only recent advances in fluid handling equipment but also what can be expected in the fairly immediate future. We hope our study will be as helpful as its predecessors.

Fresh Water from Brackish

Pure water supply is an essential of modern urban living. It is a vital requirement for a large majority of process industries. In quite a number of areas local supplies are seriously threatened by the invasion of salt water from nearby ocean, bay or elsewhere.

This problem has become one of basic chemical engineering concern. The time has come when many plants must determine the cheapest way in which to get adequate fresh water supply when major sources nearby and underground are brackish. It is not yet clear whether methods of distillation or other techniques of salt removal are going to prove generally economical or excessively costly. Probably there will be many cases in which potable water can be so made from brackish or even stronger ocean salt water.

We believe that industry is going to investigate these cases promptly and diligently. We are rather skeptical whether industry needs to have the government go into this business as proposed by Congressman Doyle in H. R. 2676. But we are grateful that Mr. Doyle is spotlighting the problem. The threat of a "Sea Water Research Act" may be what we need to get the prompt scientific and industrial investigations, that seem to us vastly more promising than government "demonstration plants to produce potable water from sea water or other liquids." Government should do research on an engineering scale, but certainly need not go into the water business.

Control of Air Pollution

Many process industries are suddenly confronted with an epidemic of criticism and some legal attacks based on the charge that air pollution is caused by factory operation. Two or three cases of major magnitude have spotlighted this problem. Unfortunately some "do-gooders" and some others whose motive seems to be trouble-making, are going about stirring up neighborhoods with what appear generally to be wholly unwarranted charges.

The problem is not new. The urgency of need for attention is. Some of this urgency has foundation in cases where neglect or conditions which were tolerable in the past are no longer to be ignored.

Another reason for urgency is the possibility that Congress will be persuaded to consider a legislative solution comparable in scope to the Water Pollution Control Act of 1948. Such an act would not be warranted in our opinion for these problems are primarily of local concern and without interstate and, therefore, federal interest.

As in the case of smoke nuisance, many of the complaints against chemical enterprise are really criticisms of neighboring activity which has no connection with the firm criticised. But it is not enough merely to say this. There must be proof that is con-

vincing. Even then, hard feeling may remain unless there is also company assistance in securing correction of any source of atmospheric nuisances.

Apparently every plant must now review every possible source of dust, fumes, smoke, odor, or other atmospheric contaminant. Facts must be secured which will permit effective methods of control and complete nuisance elimination. In many cases corrections will be easy. In others, difficult or seemingly impossible problems will be discovered. Regardless of all variables, the one inexcusable factor will be neglect to study and achieve promptly all of the corrections which are practical of accomplishment.

Red Rottenness

Creative research is, basically, a delicate state of mind that results from a rare fusion of knowledge, imagination, hard work and unwavering faith. Not the least of these is faith. And by faith we mean belief in the moral right of the individual, in the organization for which he works, and in the system of enterprise that sponsors both. Foster this faith and creative research will blossom and bear abundant fruit. Destroy it and true creativeness will wither and die.

All too often management can destroy this faith, albeit unwittingly, by showing too little faith in return. How? By failing to give proper recognition is certainly one way. Another is by a parsimonious policy of compensation, either tangible in the form of paychecks or intangible in withholding responsibility or reducing research to an obvious serfdom to sales or short-haul profits. How can a researcher be truly creative when he cannot have faith in the broader policies and basic motives of his own organization? The essence of his best efforts has lost all meaning.

But how about the researcher's broader responsibilities as a citizen? Can he think creatively for the good of a civilization in which he has no faith, which he will fight—openly or treacherously—to overthrow? No man can cling to Moscow and contribute his best to the American way of life. No man can worship one god and create for another. The mere presence of such misfits (often planted) in a research organization can quickly create the seed for a cancerous growth of dissatisfaction, inefficiency and disintegration. For there have already been cases—and there will almost certainly be more—where professional research men have been taken in, again albeit unwittingly, by the spurious logic of a handful of communist and near communist agitators. And, full of synthetic resentment and dissatisfaction, they become less than worthless in any creative research effort. Rottenness can spread in a research organization just as insidiously as in a barrel of apples.

For all of us who believe in the future of our democratic way of life, it is well to remember this: Creativeness and lack of faith do not mix—whether the cause is management's or the researcher's idealogical conviction. It is for us to see that the cultivated fields of research never become fertile for weeds, that those that do spring up are yanked out before they choke off constructive growth and progress. Creative research is the germ of our future; let us always keep it strong and virile.

Churchillian Logic

Some of the things the great Mr. Churchill said at M.I.T.'s Mid-Century Convocation last month left a rather wry taste in the mouths of the scientists. They resented the implication that their works had been turned so completely to civilization's destruction and distraction. But the engineers in his audience found some solace in his amazing tribute to technology:

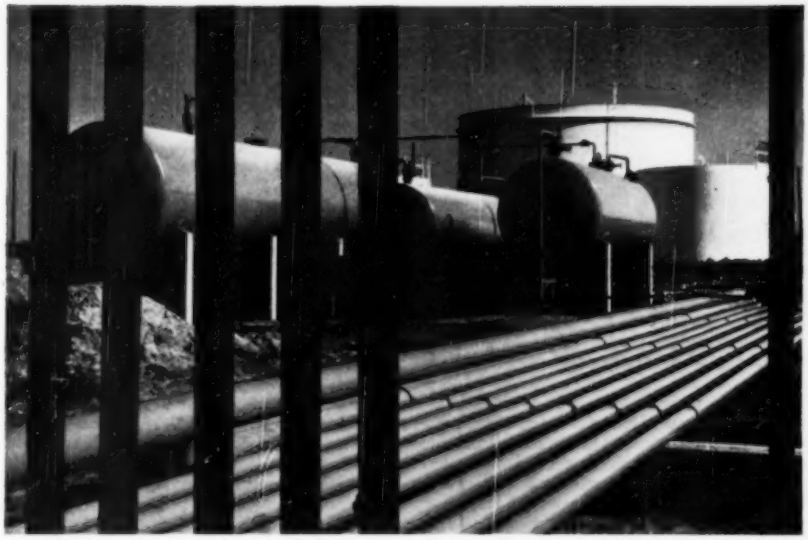
"We have suffered in Great Britain by the lack of colleges of university rank in which engineering and the allied subjects are taught. Industrial production depends on technology and it is because the Americans, like the prewar Germans, realized this and created institutions for the advance training of large numbers of high-grade engineers to translate the advances of pure science into industrial techniques—it is for this reason that their output per head and consequent standard of life are so high."

This is indeed high praise—coming as it does at a time when American engineering education has been under fire because of allegedly inadequate training in the practical applications of science and technology.

Kenneth D. Kahn 1893-1949

Driving home from a business trip to Dallas last month, our Los Angeles correspondent met with a fatal automobile accident near Amarillo, Texas. Mrs. Kahn, his able helpmate and editorial collaborator, survived but was severely injured. Thus ends their productive teamwork for chemistry and chemical engineering in Southern California.

After graduating in chemical engineering from M.I.T., Ken Kahn went to Los Angeles in 1921. Not finding work immediately in his chosen profession, he joined with his brother, Donald, in organizing a construction firm that for 20 years built many homes in Hollywood and Beverly Hills. But at the start of the war, he returned to chemical engineering, became associated with Lockheed Aircraft and soon made a name for himself in that burgeoning industry. He took a prominent part in chemical affairs, editing the very progressive Scalacs bulletin of the Southern California section of the American Chemical Society. He early offered his services to us and contributed materially to our editorial coverage of *Pacific Process Industries*. We shall surely miss him. So will thousands of friends and readers who were benefited by his enthusiasm and enterprise.



FLOW OF FLUIDS

In the 12 years since our first Fluid Flow report, tremendous progress has been made on many aspects of the science. Advances have occurred in numerous fields and in many branches of engineering. To survey those parts of the subject directly allied to chemical engineering, we present a group of 15 articles.

CHEMICAL ENGINEERING REPORT — MAY 1949

THIS report has set itself the task of attempting to survey and interpret all the more important advances in fluid flow that affect the everyday job of the chemical engineer. Obviously it is impossible to handle such a project thoroughly within the confines of 48 pages. Therefore, we have asked our authors to high-spot and to interpret, bearing in mind that the practical consequences of improvements in our knowledge of theory and technology are the things that will be most useful for engineers with problems of process and equipment design and operation.

An integrated plan

The articles that follow are part of a carefully integrated plan. The first is written by a mechanical engineer who is well known both as an investigator in the field, and as the author of a standard work on fluid mechanics. It has the difficult job of surveying the whole science and attempting to draw from it conclusions regarding the impact of developments of any kind upon fluid flow in chemical engineering. The second, prepared by a chemical engineer with long experience in interpreting fluid flow technology, presents a masterful design for visualizing fluid flow mechanisms and solving problems that arise. The remainder of the report is divided into two main parts: (1) theory and technology, and (2) the equipment of fluid flow.

Theory, technology, equipment

The first of the main divisions deals with four aspects of multi-phase fluids ranging from non-Newtonian flow to fluidization; with obstructed flow through packed beds and tube bundles; with flow at extreme low pressure; and with flow of gases at high pressure drop. The second division, on equipment, includes articles on pumps; reciprocating, and axial flow and centrifugal compressors; equipment for extreme high vacuum; and ejectors for the medium high vacuum range.

Acknowledgement must be made to many individuals for their wholehearted assistance, notably to our authors, and to those engineers who guided us in planning this report. Among the latter we must pay tribute particularly to C. E. Lapple of Du Pont, C. F. Bonilla of Columbia University, and to Benjamin Miller and Henry Eckhardt, both consulting engineers of New York.

(Over)

A Glance at Recent Fluid Flow Progress

Developments in fluid dynamics occur in so many fields that we have asked Dr. Binder to select high spots from the whole field and thus attempt to draw the loose ends together

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In chemical, and other fields of engineering, there are many applications which involve the flow or movement of some fluid. In fact, no other branch of mechanics enters into so many different forms of engineering endeavor, which is why we find parts of the whole subject of interest in pipe flow—and the study of missiles; in pumps and compressors—and in the flight of aircraft; in steam and gas turbines— and in the motion and propulsion of marine vessels. In the past few years there has been a great variety of investigational work and development in widely scattered and often very specialized parts of the field, only a comparatively small part of which was carried on by chemical engineers. The chemical engineer cannot be blamed, therefore, if he wonders what if any benefits his own particular branch of engineering may eventually reap from better knowledge in—let us say—the use of wind tunnels, or the assault of aircraft and missiles on the sonic barrier.

How chemical engineers benefit

As a matter of fact, it is not always possible to say just what benefits to other aspects of fluid flow, a development in one particular branch may bring. Certainly, we can generalize and state that whatever improves a part of a science must improve the whole. Then, sometimes we can see how advances in, say, aircraft propulsion, will inevitably aid the development of compressors and stationary gas turbines. We can see how better understanding of high-speed compressible flow will aid the improvement of ejectors and perhaps of pumps. It is already becoming obvious how advances in hydraulic power transmission during the war are being converted widely to industrial applications. And we might cite other examples, as well.

Still, our problem now is not so much one of interpreting an advance here into a specific benefit there, as it is in taking a brief look, in a series of "snapshots," at recent developments throughout the field of fluid dynamics. In so doing it may be that the engineer will be helped to an evaluation of the impact of these developments upon his own work.

Viscous versus turbulent

In so-called laminar flow the fluid moves in layers or laminas, the interaction between which is primarily molecular. This molecular interchange between layers accounts for a viscous shear or resistance to relative motion. In turbulent flow there are secondary irregular motions and velocity fluctuations which are superimposed on the principal or average flow. Differently expressed, there is molecular friction plus an additional interaction due to momentum transfer of fluid masses between adjacent layers.

Generally speaking, laminar flow can be analyzed mathematically and many practical problems have been solved directly in a rational manner. For example, laminar flow in pipes is conveniently expressed by the Hagen-Poiseuille law. This law can be derived analytically and it agrees very closely with experimental measurements.

A great deal of experimental work and theoretical work has been done on turbulence, which is very common in practice. Better understanding and a more rational analysis of turbulence could be extremely helpful in a wide range of industrial applications. Nevertheless, the exact nature and mechanism of turbulent flow have not been completely established at the present time.

Some ten years ago L. Prandtl and T. v. Kármán presented a number of basic concepts which are becoming better established. Various refinements and applications have been presented, but the basic concepts have not been radically changed.

Mixing length

Prandtl is credited with introducing the concept of "mixing length." In describing molecular motion we are accustomed to the term "mean free path" of the molecule, which means the average distance a molecule travels between collisions. "Mixing length" is analogous to "mean free path." The concept is that, in turbulent exchange, the fluid masses displaced perpendicular to the direction of mean flow carry momentum (mass times velocity) over a certain length perpendicular to the mean flow. The mixing length is defined as the average distance perpendicular to the main flow covered by the mixing particle. The turbulent shear stress is proportional to the square of the mixing length. This length is useful in trying to gain an understanding of the fundamental laws of turbulent flow. In this direction, von Kármán developed the concept that mixing length is a function of some universal numerical constant and factors dependent on the velocity gradient.

These concepts have been applied to such problems as the velocity distribution in pipes and the resulting logarithmic relations seem to provide a sound basis or starting point for organizing data.

Boundary layer

As fluid flows along a surface or a solid boundary, there is a very thin layer of fluid which adheres to the surface and thus has a zero velocity with respect to that surface. Normal to the wall is a region where fluid is retarded by the wall, and in it there is a velocity variation; this region is called the "boundary layer."

Boundary-layer flow is important in connection with studies of friction and heat transfer. Boundary layer or velocity profiles for flow in pipes and along flat plates are becoming well established, though such flow for certain other types of channels is not so well established.

One type of effect caused by the boundary layer is illustrated in diffusers. A nozzle is a channel in which the velocity of the fluid is increased and the pressure reduced, whereas in a diffuser the opposite effects are secured. For an incompressible fluid a nozzle is formed by a converging channel where the fluid is accelerated, and some pressure head is converted into velocity head. In general, this conversion is a stable process, and can be made with low losses.

On the other hand, a diffuser for an incompressible fluid is formed by a diverging channel. Flow in a diffuser is one of the most common, most important, and most troublesome problems in practice. Diffusers are found in all sorts of piping systems and fluid machines; examples are water and gas piping systems, the passages through fan and pump blades and ejectors, and some fluid meters.

Boundary layer in diffusers

As fluid moves downstream in a diffuser, a boundary layer is formed and grows in thickness. Energy is lost because of molecular action as adjacent layers of fluid near the wall slide by each other. Also, the fluid may not fill the channel completely. It may break away from the walls or "separate," with the result that eddies are formed and energy is dissipated by turbulent mixing. Thus, flow in a diffuser may be an unstable, inefficient process, accompanied by large losses and appreciable eddying regions.

It appears now that turbulent boundary-layer flow cannot be analyzed by a simple rational approach. The best that can be done, it seems, is to try to get convenient organizations of experimental data. Various studies are now being made, but the problem is not completely solved. If and when more data on boundary-layer flow become available, we should be able to make a better approach to many practical problems, including the reduction of energy losses and the development of more efficient flow channels and machines.

Mathematical approach

During this century there has been a great deal of purely mathematical work in the field of fluid flow. Powerful techniques of analysis have been developed and some of these studies have been very elegant and complicated. Frequently one wonders whether experimental confirmation of the theory will ever be secured. One interesting confirmation was found recently.

Over 40 years ago investigators proposed a mathematical theory of stability for laminar boundary-layer flow along a flat plate, predicting certain oscillations in the boundary layer. For many years preliminary experiments failed to show these oscillations and the theory was discredited. Recently, however, some careful boundary-layer tests showed the oscillations,[9] thus confirming a purely mathematical theory of many years standing.

Fluid flow in pipes

For a long time experimental work has been carried out on the flow of incompressible fluids in pipes, and the results have been well established. Both the isothermal and the adiabatic flow of gas in pipes have been established. Recently, however, attention has been focused on the compressible flow of gases in pipes, accompanied by heat transfer.[10] Interest has been provoked by such applications as flow in combustion chambers and in heat exchangers. Little experimental information is available yet, but analytical studies have shown certain trends.

Acoustic velocity

Each fluid at a given temperature and pressure has a so-called "acoustic velocity" which is the velocity of sound in the fluid. For air at 59 deg. F. and 14.7 psia. this acoustic or sonic velocity is 1,120 fps. which means that a pressure disturbance or wave will travel through such air with a speed of 1,120 fps.

Some of the work mentioned was concerned with compressible, frictionless flow in pipes of constant diameter, combined with heat transfer. Consider a flow which is initially subsonic. As this gas flows down the pipe, the velocity increases as heat is added, and the pressure drops. Analytical work shows that the highest possible velocity is the sonic velocity and at this velocity there is a maximum amount of heat which can be added to the gas. At the limiting velocity the lowest possible pressure in the pipe is reached. Thus, there appear certain limiting conditions for gas flow with heat transfer, which may be of great importance in combustion chambers and heat exchangers.

Attempts have been made to analyze compressible flow in pipes, with both heat transfer and friction. The mathematics becomes complicated, and some indirect procedures have been proposed. A more explicit solution with friction included, and more experimental data, would be helpful particularly to engineers concerned with gas flow.

High velocity flight

Most dramatic and highly publicized of all current work on fluid flow is that on wind tunnels, aircraft flight, and jet propulsion. Much of this will probably have little direct concern for chemical engineers and yet it will surely have byproduct results in better understanding of airfoil sections—which go into turbine and axial compressor blading; in better appreciation of the problems of supersonic velocities; in improved combustion methods; and in construction materials for high stresses at elevated temperatures. Furthermore, high velocity flight involves direct application of basic compressible flow phenomena which, as such, are part of the body of fundamental theory.

Mach number

In current research literature on compressible flow one finds frequent mention of the Mach number, which is simply the ratio of the exist-

ing fluid velocity, divided by the velocity of sound. For subsonic flow the Mach number is less than unity, for supersonic flow it is greater. A dimensionless ratio, the Mach number is useful particularly in correlating data. Mach number squared is proportional to the ratio of inertia force to compressible or elastic force—both forces important in high velocity flow. For a gas, molecular kinetic energy is proportional to absolute temperature. Mach number squared is also proportional to the ratio of flow velocity squared to absolute temperature. Thus, for a gas, Mach number squared can be regarded as a ratio proportional to flow kinetic energy divided by molecular kinetic energy.

Compressible flow

Much theoretical and experimental work has been done in the field of compressible flow. Some of this work has been provoked by industrial machinery such as compressors and turbines, and some by applications in aircraft flight.

Generally speaking, this recent work has not resulted in any startling or radically new flow phenomena. However, it has helped to clear up details regarding the mechanism of flow and to provide, in some cases, a better understanding of common flow actions.

As an illustration of this general conclusion, consider the steam-jet ejector. This device has been used for many years in vacuum applications, and many operators know its characteristics. Still, although we know how the device acts, we do not know exactly why. The flow in it is complicated. Some of the recent work has uncovered certain details of flow which improve our understanding of some features of the ejector. Still, it does not give us a complete picture. It may be some time before a complete, rational analysis of the ejector will be possible. The same is true of other fluid machinery.

Dimensional flow

In so-called "one-dimensional" flow the velocity is constant across each cross-section, with variation in velocity only in the dimension of the flow direction. So-called "two-dimensional" flow refers to flow which is identical in parallel planes. There may be a variation in the direction of flow and at the same time a variation at right angles to the flow direction in the parallel planes.

The analytical relations for one-dimensional, compressible, frictionless flow through a converging-diverging passage have become better established in recent years. These relations are complicated. Certain tables for gas flow have been published which are helpful if one has many similar problems in this field. At the same time, analytical relations have become better established for subsonic two-dimensional flow around a body. Some of the background mathematics is very difficult, but certain of the final relations are relatively simple and of practical value. For example, there is this problem: If we know the pressure distribution around a body at low velocities, what is the pressure distribution at higher Mach numbers? Von Karman and Tsien[3] have developed an extrapolation law for subsonic flow which agrees fairly well with experimental results.

Some of the recent publicity tends to give the impression that supersonic flow is a very new phenomenon. This impression is not correct. Projectiles and bullets have been moving at supersonic speeds for many years and certain aspects of supersonic flow from the field of ballistics have been established for a long time. Also, supersonic flow has existed in many steam and gas turbine parts and in ejectors, a fact established some time ago. Thus, in many respects, the problem of supersonic flight associated with current aircraft is primarily a new application rather than a basically new flow phenomenon.

In supersonic flow of a gas there is a wave action analogous to the motion at the free surface of a body of liquid. This occurs because the fluid moves faster than the pressure wave can be "telegraphed" through the fluid. The bow wave in front of a boat moving on the surface of a body of water is analogous to the bow pressure wave in a gas in front of a projectile.

Compression shock

Generally speaking, as fluid flows in a passage, the transition from subsonic to supersonic flow is not as troublesome as the transition from supersonic to subsonic. The latter change may occur suddenly and in a very short distance, as in the so-called "compression shock." Across this shock there may be a marked increase in pressure, a sharp decrease in velocity, and considerable impact resulting in a degradation of energy. Thus, in some flow channels where supersonic flow is changed to subsonic, the energy conversion may be quite inefficient, and the performance not as desired. As more experimental data become available, we may be able to gain a better understanding of the compression shock and means for controlling it.

Flow at low pressure

Engineers are now gaining familiarity with subsonic flow of gases in pipes at low pressures, say, below 1 in. Hg abs. Both theoretical and experimental information is available for this type of flow, as attested by the large number of installations at pressures down to and below the micron range. However, there is a real lack of both sorts of information for supersonic flow in rarified gas.

Attempts to get such information are being provoked in order to solve problems concerned with flight at extreme altitudes.[4] In many applications of flow it is sufficiently accurate to consider fluids as continuous media, with the flow phenomena studied by reference to bulk properties, without a detailed consideration of the behavior of the molecules. However, when the molecular mean free paths are appreciable, as in supersonic flow in a rarefied gas, it is necessary to describe the fluid on the basis of its individual molecules. Work already started in this field may have benefits in industrial applications.

Several sorts of fluid flow problem are presently of much practical interest. Among them we should glance at cavitation, ultrasonics, and some of the developments in equipment.

Flow with "boiling"

As a liquid flows through a machine or stationary passage, a vapor or gas phase may co-exist with the liquid phase. Such two-phase flow, or liquid flow with boiling, is usually called flow with cavitation. Cavitation may lead

to two serious and undesirable effects: a marked drop in efficiency of energy conversion, and a dangerous erosion or pitting of some of the metal parts. The performance of a centrifugal pump, for example, may be seriously affected by cavitation and its runner may be pitted and even worn away.

Pictures of cavitation

Recently material was published[4] which for the first time gave the life history of a cavitation bubble, its growth, collapse, and rebound. New experimental equipment and methods were devised. Tests of the flow around bodies of revolution, with different nose shapes, were made in a high-speed water tunnel. Photographic records were taken, using a new development in motion picture photography, with pictures at varying rates up to 20,000 per second. The observations led to certain conclusions concerning the physical mechanism of the cavitation phenomenon. After the first growth to maximum diameter, and the first collapse to disappearance, three to five rebounds and recollapses of the same bubble were observed before ultimate disappearance. Strong inference is furnished that the pressure within the spherical bubble is approximately equal to the vapor pressure of the liquid at the mean temperature of the flow. There are indications that very high surge pressures are developed.

Basic data of this sort should lead to a better understanding of two-phase flow. Possibly, too, improvement, in pumps, agitators and marine propellers will result.

One trend that deserves watching is the use of so-called "ultrasonics."[3, 9] The normal human ear responds to an air or fluid vibration up to around 16,000 to 18,000 cycles per second. An ultrasonic vibration of a fluid, therefore, is one with a frequency above human ear response. Ultrasonic vibrations in air, water, and other fluids have been generated in engineering studies up to and above 200,000 cycles per second.

Ultrasonic processes

These high frequency vibrations have many unique and attractive features. They have coagulated smoke and dust suspensions in gases, and they have dispersed colloidal suspensions in liquids. Immiscible liquids, such as water and oil, or water and mercury, have been so transformed into stable emulsions. There seems to be much promise in the application of ultrasonics to the manufacture of catalytic agents. Melts of tin, zinc, and aluminum have been solidified more rapidly when subjected to high frequency vibrations, whereas liquids have been degassed because the liquid expands under treatment and a negative pressure is developed. Milk can be homogenized by ultrasonics. High frequency vibrations transferred through a fluid to metal can be used in non-destructive testing of plates, castings and forgings.

Research and development in this general field are far from complete. Much of the work is still in the scientific, small-scale laboratory stage. Some industrial plant developments have been started, however, including the coagulation of dust suspensions in air, the collection of acid fumes, and the coagulation of carbon black particles suspended in gas. Eventually applications may be numerous.

Another recent field of development has been in fluid couplings and fluid torque converters. These devices have certain characteristics which are useful in industrial drives. Although purely mechanical devices are used in many applications, in others the service requirements are best met by some form of fluid connector.

Fluid coupling principles

A fluid coupling is simply a combination of a centrifugal pump and a turbine. Oil is usually employed in commercial units for the working fluid because of its lubricating properties, stability, and availability. The principle of the fluid coupling can be easily demonstrated by means of two ordinary electric fans which are set facing each other. One fan, connected to an electric outlet, is put into motion by turning on the electric current. As its blades rotate, the air current which they develop turns the blades of the other fan.

Since there are no torque reacting elements in the fluid coupling besides the pump impeller and turbine runner, under steady operating conditions the output torque always equals the input torque and, at normal speeds and loads, the efficiency may be as high as 96 to 99 percent. Acceleration of the output shaft is smooth and the load may be stalled completely without stalling the driver.

A fluid torque converter differs from a fluid coupling in including a series of fixed guide vanes which change the direction of the fluid and make possible a torque and speed transformation.

Axial flow machinery

In the field of prime movers, both for stationary and vehicle applications, there have been developments in axial-flow machinery, especially fans and compressors. These developments are leading to improved machinery for industrial plant use.

Generally speaking, there are two types of blading used on axial-flow fans and compressors. In one type the blades are far enough apart that they do not exert much influence on each other. In the other type the blades are closely spaced—the so-called "lattice" type of runner where the blades exert a definite guiding action on the fluid.

Such machines give relatively high rate of flow and small pressure boost, as compared with a centrifugal compressor. Theoretical studies and preliminary experimental results indicate that the lattice type of fan or compressor shows promise of giving higher pressure boosts than was common in the past. If this possibility materializes, some very useful improvements in industrial equipment may be expected.

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Velocity Head Simplifies Flow Computation

Familiarity with the velocity head concept not only speeds flow calculations but aids greatly in visualizing flow problems

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Chemical engineers must often make calculations dealing with the flow of fluids. These may involve the determination of pressure drop in a pipe or other conduit, a meter, or piece of process equipment. Or conversely, with a given pressure drop available, it may be necessary to determine the flow rate for a given diameter, or the diameter needed for a given flow rate. When a fluid is to be moved, the pressure drop must be known to specify the pump, fan or compressor. Furthermore, in the operation of equipment, pressure drop calculations are often useful in locating plugged or corroded lines. Sometimes such estimates must be made to determine whether and where bottlenecks will exist if capacity should be increased. Finally, it is sometimes necessary to be able to make reasonable flow or pressure drop estimates in equipment for which specific data are not available.

FLOW MECHANISMS

A great deal of study has been devoted to fluid flow, and calculation methods have been evolved to deal with many types of conduits and equipment. Many of the expressions derived are relatively complex, which has led to the development of certain rules-of-thumb that are sometimes used as a guide or for checking the order of magnitude of more complex calculations. However, as this paper shows, by gaining an insight into fluid flow mechanisms, it is possible to visualize frictional and pressure drop processes. From this, simplified equations can be developed for rapid estimation or for checking more accurate calculations. The method facilitates the approach to more accurate calculations and also enables the engineer to make order-of-magnitude estimates in the field or when data are lacking.

Fluid flow may be either streamline or turbulent and may in the same conduit change from one to the other as certain variables are altered.

In streamline flow, which is also called viscous or laminar, the adjacent layers of moving fluid slip over each other (like so many concentric cylinders in the case of pipe flow), without mixing or interchange of fluid from one layer to the next. In such flow the frictional losses are due directly to shearing between adjacent layers and these losses, which show up as pressure drop, are proportional to the first power of the flow velocity.

In turbulent flow, however, the fluid motion is characterized by an eddying of the fluid within itself, in addition to the movement of the whole body of fluid in a given direction. The adjacent layers do not shear smoothly over each other but are continually interchanging portions of fluid. Hence the friction losses are due to random shearing and impact of the fluid exchanged between layers. Turbulent flow ensues when the inertia forces predominate over the viscous forces within the fluid. Hence, the frictional losses, expressed as pressure drop, are more nearly proportional to the square of the flow velocity, which is a measure of the magnitude of the inertial forces.

Whether the flow will be streamline or turbulent in any case therefore depends on the ratio of inertia to viscous forces. A method of expressing this ratio is the Reynolds number $N_{Re} = DV\rho/g$, which is the criterion customarily used for determining the character of flow and for the plotting of friction data. When this ratio is less than a certain critical value which varies with the sort of flow path (approximately 2,000 for flow in straight cylindrical pipes), streamline flow exists, while the flow is generally turbulent at values greater than 2,000. In practice, more than 98 percent of all fluid flow problems fall in the turbulent range.

When the flow is turbulent, the pressure drop is largely a measure of the potential energy, which is converted to kinetic energy of the fluid. This kinetic energy may subsequently be dissipated as heat by impact or general turbulence, or a part at least may be recovered subsequently as pressure if the fluid expands or decelerates. A small part of the pressure drop may be due directly to frictional shearing between fluid layers. When this loss is appreciable, the pressure drop will be a function of the Reynolds number. However, when this factor is negligible and pressure drop is due almost entirely to acceleration or deceleration of the fluid, then the pressure drop will be substantially independent of the Reynolds number.

Typical of cases dependent on the Reynolds number are many conditions encountered in practice, such as flow through pipes, tube banks, or beds of granular solids. Here frictional losses are appreciable even though the flow is turbulent. Flow through orifices, nozzles and venturis is characteristic of the second case where pressure drop is independent of the Reynolds number and frictional losses are negligible.

ENERGY RELATIONS IN FLOW

When a fluid is flowing, it suffers a drop in pressure which may be the result of a conversion of pressure energy into kinetic energy, or into potential energy caused by a change in elevation. On the other hand, the pressure drop may result from a dissipation of pressure energy into heat by frictional losses. This distinction is important, since it emphasizes the difference between pressure drop and friction loss. The first represents the total difference in fluid pressure between two points in a system. It may or may not involve a loss in available energy, whereas the second represents only that portion of the pressure energy which is lost as heat and therefore becomes unavailable.

Pressure drop and friction loss are related by Bernoulli's theorem which applies in the form given where no mechanical work is done by or on the fluid between the points in question:

$$\Delta p = p_1 - p_2 = \left[\frac{\rho V_2^2}{2g_c} - \frac{\rho V_1^2}{2g_c}\right] + \left[\rho Z_2 - \rho Z_1\right] + F \qquad (1)$$

This equation states that the drop in pressure from point (1) upstream to point (2) downstream equals the algebraic sum of the increase in kinetic energy, plus the increase in potential energy due to elevation, plus the friction loss. In horizontal equipment with the same inlet and outlet

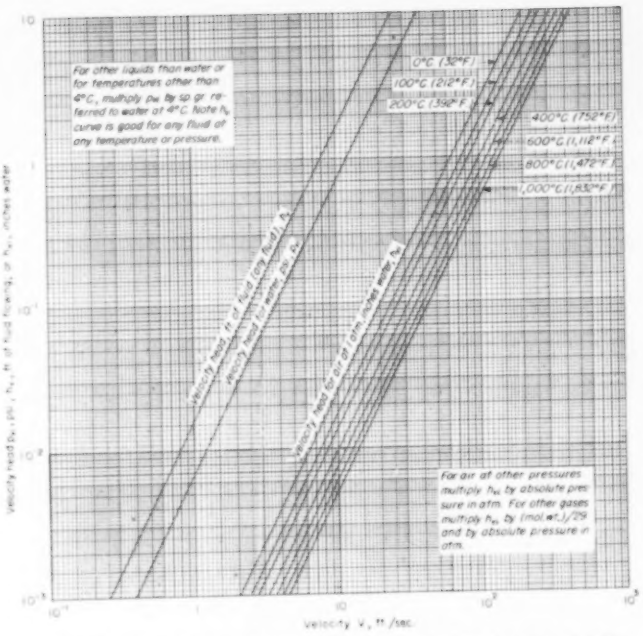
For other liquids than water or for temperatures other than 4°C., multiply p_w by sp gr referred to water at 4°C. Note h_w curve is good for any fluid at any temperature or pressure.
0°C (32°F)
100°C (212°F)
200°C (392°F)
400°C (752°F)
600°C (1,112°F)
800°C (1,472°F)
1,000°C (1,832°F)
For air at other pressures multiply h_w by absolute pressure in atm. For other gases multiply h_w by (mol.wt.)/29 and by absolute pressure in atm.
Velocity head p_w, psi; h_w, ft of fluid flowing, or h_{wi}, inches water
Velocity V, ft/sec

Fig. 1—Velocity head for air at 1 atm. and various temperatures; for water at 4 deg. C.; and for any fluid in feet of the fluid under existing conditions.

area there will be no change in either the kinetic energy or the potential energy provided the fluid density does not change appreciably. In this case, therefore, the overall friction loss and pressure drop are identical.

VELOCITY HEAD CONCEPT

The various forms of energy in a fluid system can be considered as "heads" since they can be expressed as an equivalent potential energy or height of fluid column. Thus the difference in elevation between two points in the flow path is a head, the static pressure at any point is equivalent to a head, and the kinetic energy of motion of the fluid is also equivalent to a head, which is called the velocity head. In a turbulent flow system where inertia forces or changes in kinetic energy are predominant, pressure drop and friction losses can be visualized in terms of the kinetic energy of the fluid.

This concept of kinetic energy as an equivalent pressure differential or velocity head, and its use in pressure drop or friction loss calculations, is useful only under turbulent flow conditions. The velocity head concept is not novel and has long been employed by ventilating and hydraulic engineers. However, it is not adequately described in the literature and its physical significance and practical utility are not widely appreciated.[a]

FORMS OF VELOCITY HEAD

Where a fluid is flowing with velocity V, each pound has a certain kinetic energy defined by:

$$E_v = V^2/2g_c \qquad (2)$$

where g_c is a conversion factor numerically equal to the standard acceleration of gravity. Its use is necessary because of the confusion arising from the use of "pound" as a unit of both mass and force. Since the kinetic energy can be expressed as a pressure differential, it is desirable to list equations for the alternate methods and units in which this differential or velocity head can be stated for any fluid:

$$p_v = \rho V^2/2g_c \qquad (3)$$

$$p_{vi} = \rho V^2/288g_c \qquad (4)$$

$$h_v = V^2/2g_L = (V^2/2g_c)\,(g_c/g_L) \qquad (5)$$

$$h_{vi} = 0.00200\,\rho V^2 \qquad (6)$$

In Equation (5) the ratio of g_c/g_L (numerically equal to unity) is introduced only to maintain the equation dimensionally correct (Ref. 4, p. 800). This equation, expressing the kinetic energy of a unit mass of fluid as an equivalent height of fluid column is the one which originally gave rise to the term "velocity head."

Since in what follows we shall have occasion frequently to use the velocity head, it will be convenient to find it from a chart without calculation. Fig. 1 gives curves for velocity head in terms of feet of the fluid h_v for any fluid, as well as in pounds per square inch p_{vi} for water at 4 deg. C., and inches of water column h_{vi} for air at 1 atm. and several temperatures. The p_{vi} curve is readily corrected for other temperatures or fluids, and the h_{vi} curves for other pressures or gases.

Similarly, Table I presents several values of the velocity head for specific fluids and velocities. These values are readily memorized and from them values for other fluid velocities or densities can readily be obtained by mental cross-ratioing.

Table I—Approximate Velocity Head Values for Various Fluids

Fluid	Fluid Velocity, Ft. per Sec.[a]	Velocity Head, Various Units
Air (125° F., 1 atm.)	30	¼ in. water
	70	1 in. water
	100	2 in. water
	200	8 in. water
Water	4	0.1 lb./sq.in.
	10	0.7 lb./sq.in.
Any fluid	8	1.0 ft. fluid
	20	6.0 ft. fluid

[a] For other velocities the corresponding velocity head may be obtained by multiplying the value in the table by the square of the ratio of the actual velocity to the velocity in the table. Since the velocity head is directly proportional to fluid density, for gases other than air the tabular value can be multiplied by the ratio of the actual mol. weight to 29.0 (air), as well as by the proper absolute temperature and pressure ratios. With liquids other than water, p_{vi} in lb. per sq. in. can be found by multiplying the tabular value for water by the specific gravity.

PRESSURE DROP CALCULATIONS

In calculations of pressure drop or friction losses, the velocity head concept is useful in that it allows the pressure drop or friction loss to be expressed as a certain number of velocity heads. Since this number is a dimensionless ratio, the actual pressure drop or friction loss determined from the value of the velocity head will have the same units as the velocity head. In cases such as pipe flow, where the pressure drop is a function of the Reynolds number, the drop expressed as a number of velocity heads will vary somewhat with the Reynolds number, although it can be approximated within reasonable limits of accuracy over the usual Reynolds number range by use of an average value for the friction factor. However, where the pressure drop involves little or no friction loss, as in flow

Nomenclature

C	= Discharge coefficient for head-type meters, dimensionless: approx. 1 for std. single-bend pitot tubes; 0.855 for double long-bend pitot tubes; 0.98-0.99 for venturis and nozzles; 0.61 for sharp-edged orifices.
D	= Inside diameter of circular pipe, ft.
D_c	= Clearance between tubes in a tube bank, ft.
D_h	= Hydraulic diameter = 4 × cross-sectional area ÷ "wetted" perimeter = D for circular pipe.
D_o	= Orifice diameter, ft.
D_p	= Diameter of granular particle, ft.
E_v	= Kinetic energy of fluid, ft.-lb. force/lb. mass.
f	= Fanning friction factor for flow in conduits, dimensionless.
f_t	= Friction factor for flow across tube banks, dimensionless.
f_b	= Friction factor for flow through beds of granular solids, dimensionless.
F	= Friction loss, lb. force/sq. ft. (Friction loss is often defined as energy loss per unit mass of fluid, or ft.-lb. force/lb. mass. This definition of friction loss is equivalent to F/ρ).
F_v	= Friction loss expressed as number of velocity heads, dimensionless.
g_c	= Conversion factor, 32.17 (lb. mass/lb. force) (ft./sec.^{2}).
g_L	= Local acceleration due to gravity, ft./sec.^{2}.
h_v	= Velocity head, ft. of fluid flowing.
h_{vw}	= Velocity head, in. of water.
K_1, K_2	= Experimental constants involved in abrupt inlet friction loss, dimensionless: for $\alpha < 0.715$, $K_1 = 0.4$ and $K_2 = 1.25$; for $\alpha > 0.715$, $K_1 = 0.75$ and $K_2 = 1.00$.
L	= Length of straight horizontal pipe, or depth of bed of granular solids in direction of flow, ft.
L_e	= Effect of valve or fitting expressed as equivalent length of straight pipe of same nominal size, ft.
$(L/D)_e$	= Number of diameters of pipe, equivalent to length of straight pipe, for which pressure drop is one velocity head, dimensionless.
N	= Number of rows of tubes normal to general direction of flow, dimensionless.
N_{Re}	= Reynolds number, dimensionless = $DV\rho/\mu$ for flow through pipes, orifices, nozzles, venturis; $D_c V_{max}\rho/\mu$ for flow across tube banks; $D_p V\rho/\mu$ for flow through beds of granular solids.
p	= Fluid pressure, lb. force/sq. ft.
p_v	= Velocity head, lb. force/sq. ft.
p_{vi}	= Velocity head, lb. force/sq. in.
Δp	= Pressure drop, lb. force/sq. ft.
Δp_v	= Pressure drop expressed as number of velocity heads, dimensionless.
q	= Volumetric fluid flow rate, cu. ft./sec.
V	= Average fluid velocity, ft./sec.
V_{max}	= Maximum average fluid velocity through tube banks, ft./sec.
x	= Distance between flat plates, ft.
Z	= Elevation of fluid above arbitrary datum plane, ft.
α	= Ratio of flow cross-section areas, dimensionless, value less than 1.
ρ	= Fluid density, lb. mass/cu. ft.
μ	= Fluid viscosity, lb. mass/(sec.) (ft.) = centipoises ÷ 1,488.

through nozzles and orifices, the drop expressed as a number of velocity heads will be substantially constant and independent of the Reynolds number.

The equations presented below are the conventional ones for pressure drop and friction loss, modified to emphasize the velocity head. In this way it is possible to bring out their physical significance more effectively than in the usual forms. In all cases it is assumed that the fluid density does not change more than 20 percent in flowing through the pipe or other apparatus, so that an average density can be used. If greater density changes occur, as with flow of gases at high pressure drops, then special methods of calculation must be used.* (See also C. E. Lapple, p. 125, this issue.)

Pipes and Conduits

Although there are various equations for friction loss or pressure drop in straight, horizontal, cylindrical pipes, the one most commonly used is the Fanning equation:

$$F = \Delta p = (4fL/D)(\rho V^2/2g_c) \qquad (7)$$

Table II—Pressure Drop for Turbulent Flow through Screwed Valves and Fittings

Type of Valve or Fitting	Pressure Drop[1] As Equiv. Diameters of Pipe, L_e/D	Pressure Drop[1] As Equiv Vel. Heads, Δp_v
45° ell, std	15	0.3
45° ell, long radius	10	0.2
90° ell, std	32	0.74
medium sweep	26	0.6
long sweep	20	0.46
square	60	1.3
180° bend, close return	75	1.7
medium radius	50	1.2
Tee, std., along run, branch blanked off	20	0.4
used as ell, entering run	60	1.3
used as ell, entering branch	70	1.5
branching flow	.....	1.0[2]
long radius, used as ell, entering run	30	0.5
Couplings	2	0.04
Unions	2	0.04
Gate valves[3], open	7	0.13
¼ open	40	0.8
½ open	200	3.8
¾ open	800	15.0
Globe valves[4], bevel seat, open	350	6.3
½ open	550	10.0
composition disk, open	330	6.0
½ open	500	9.0
plug disk, open	500	9.0
¼ open	700	13.0
½ open	2,000	35.0
¾ open	6,000	110.0
Angle valves[4], open	170	3.0
Y or blow-off valves[4], open	170	3.0
Check valves, swing[5]	110	2.0
disk[4]	500	10.0
ball[6]	3,500	65.0
Water meters, disk	400	8.0
piston	600	12.0
impulse wheel	300	6.0

[1] Pressure drop expressed as for straight pipe of same nominal size as the fitting. Where expressed as L_e/D, L_e is equivalent length of straight pipe, ft., and D is actual pipe I.D., ft. Where expressed as velocity heads, pressure drop is based on velocity in pipe of same nominal diameter as fitting. [2] Velocity head in main stream before branching. Depends on relative flow split. Ranges from 0.7 to 1.3 if main stream enters run, and from 0.9 to 1.5 if main stream enters branch. This is pressure drop (not friction loss) between run and branch. [3] Flow direction through valves has negligible effect on pressure drop. [4] Values apply only when check valve is fully open, which generally is attained at pipe velocities over 3 ft./sec. for water.

in which the friction factor f is a function of the Reynolds number and the second group of terms in parentheses is the velocity head as given in Equation (3). Equation (7) may be expressed in the form:

$$\Delta p_v = \Delta p/(\rho V^2/2g_c) = 4fL/D \qquad (8)$$

where the pressure drop is expressed as a certain number of velocity heads equal to $4fL/D$. If we express the length of pipe as equivalent to a number of pipe diameters L/D, then it is obvious that a certain number of pipe diameters will have a pressure drop of 1 velocity head ($\Delta p_v = 1$) and:

$$(L/D)_e = 1/4f \qquad (9)$$

For these equations the value of f may be determined from the Reynolds number* by means of Fig. 2. This chart also gives values of $(L/D)_e = 1/(4f)$, plotted as a dot-dash curve vs. N_{Re}. However, for many purposes, the value of f can be approximated without using the chart. Most process industry designs lie in the N_{Re} range of 5,000 to 1,000,000 which, from the chart, means a range of f from 0.004 to 0.010 for clean commercial steel pipe.

Thus, $f = 0.0055$ is a good average for rough estimates over the entire range. With this value Equation (9) gives $(L/D)_e = 45$, meaning that 45 diameters of clean commercial pipe will have a pressure drop of 1 velocity

* If the calculated value of N_{Re} is less than 2,000, showing streamline flow, the velocity head concept cannot be used to advantage. Instead, the Hagen-Poiseuille equation should be used by inserting the value of f in the viscous region, $f = 16/DV\rho$, into the Fanning equation of Equation (7). This gives the Hagen-Poiseuille equation, $\Delta p = 32\mu LV/g_c D^2$.

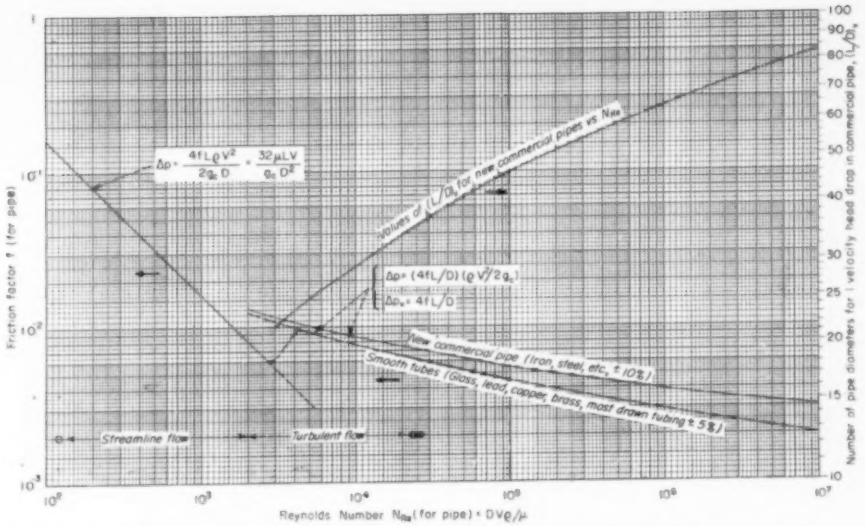
Friction factor f (for pipe)
Number of pipe diameters for 1 velocity head drop in commercial pipe, L/D
Reynolds Number N_Re (for pipe) = DVρ/μ
Δp = 4fLρV²/2g_c D = 32μLV/g_c D²
Values of (L/D)_s for new commercial pipes vs N_Re
Δp = (4fL/D)(ρV²/2g_c)
Δp = 4fL/D
New commercial pipe (Iron, steel, etc., ± 10%)
Smooth tubes (Glass, lead, copper, brass, most drawn tubing ± 5%)
Streamline flow
Turbulent flow

Fig. 2—Friction factors and values of $(L/D)_s$ vs. Reynolds number for flow through straight, cylindrical, smooth and commercial pipe.[7, 11]

head within ± 40 percent. This common rule-of-thumb can be improved by distinguishing between average values of f one is apt to encounter in water and in air handling equipment. Water flow problems generally fall in the range of N_{Re} from 10,000 to 100,000, and air handling problems, in the range of N_{Re} from 50,000 to 1,000,000. That is, in handling water, usually from 30 to 45 pipe diameters will have a pressure drop of 1 velocity head, and in handling air, the range will be 40 to 65 pipe diameters. Thus, within ± 25 percent $(L/D)_s$ may be taken at 40 (i.e., $f = 0.0062$) for water handling, and at 50 (i.e., $f = 0.0050$) for air handling.

Example 1—What is the pressure drop through 200 ft. of straight horizontal Sch. 40 pipe of 2-in. nominal diameter, handling 50 gpm. of water? The flow rate is $50/(7.48 \times 60) = 0.1114$ cu.ft./sec. Since the actual pipe I.D. is 2.067 in., the pipe area is $\pi\ (2.067)^2/(4 \times 144) = 0.0233$ sq.ft. The pipe velocity is therefore $0.1114/0.0233 = 4.78$ ft./sec. and the pipe velocity head is $4.78^2/(2 \times 32.17) = 0.36$ ft. of water. For an approximate solution assume $(L/D)_s = 40$. Then $L/D = 200 \times 12/2.067 = 1{,}160$ pipe diameters and $\Delta p_v = 1{,}160/40 = 29$ pipe velocity heads, whence the pressure drop is $29 \times 0.36 = 10.5$ ft. of water. For an accurate solution, $N_{Re} = (2.067\ 12) \times 4.78 \times 62.2 \div (1.488/1) = 76{,}000$. From Fig. 2, $f = 0.0057$ and $(L/D)_s = 44$. Hence $\Delta p_v = 1{,}160/44 = 26.4$ pipe velocity heads, or from Equation (8), $\Delta p_v = 4 \times 0.0057 \times 200 \div (2.067/12) = 26.4$ pipe velocity heads and $\Delta p = 26.4 \times 0.36 = 9.5$ ft. H_2O.

Although the discussion up to this point has applied to cylindrical pipe, the same equations and friction factors can be used for turbulent flow in other pipe cross-sections if the proper equivalent diameter is used in calculating L/D or N_{Re}. This is the hydraulic diameter D_e, which is four times the cross sectional area divided by the wetted perimeter. The velocity must of course be calculated from the actual cross-sectional area.

Thus far we have been considering the calculation of pressure drop or friction loss. Such a problem is straightforward since both D and V are known. However, when a pipeline must be designed for a given capacity, the diameter is usually determined by a more complex process to obtain the so-called economic pipe diameter that will result in lowest annual operating costs (see Ref. 4, p. 817). With this diameter the pressure drop for the system can be calculated as discussed above. However, in cases where a given pressure drop is available, the economic diameter may not be applicable and it may be necessary to determine a diameter which will handle the desired flow rate without exceeding the available pressure drop. Since neither D nor V is known a trial-and-error solution is ordinarily employed. For practical design, however, there are two simple alternate methods which give a direct solution:

Method 1—Substituting for V in Equation (7) in terms of D and q, and solving for D, we get:

$$D = \left[\frac{8\ \rho\ L\ q^2}{g_c \pi^2\ \Delta p\ (L/D)_s} \right]^{1/5} \qquad (7a)$$

Because of the 1/5th root relation, the value of D is quite insensitive to values chosen for $(L/D)_s$ and for practical purposes we may, as already discussed, take a value of 40 for this term, and so permit a direct solution for D.

Method 2—A second method, also employing the flow rate and pressure drop, utilizes the velocity head concept directly, and lends itself to mental cross-ratioing. We first assume a pipe size D_a and express the available pressure drop as Δp_{va} velocity heads for this size. The required size can then be found in terms of the assumed size:

$$D = D_a \left[\frac{(L/D_a)}{\Delta p_{va}\ (L/D)_s} \right]^{1/5} \qquad (7b)$$

where subscript (a) refers to values corresponding to the assumed pipe size. Here again an approximate value of $(L/D)_s$ suffices for practical purposes.

It is interesting to note that the second method will give entirely reliable results even if the assumed pipe size is wide of the mark. Although the velocity head and velocity calculated for the assumed size may be absurdly high or low from a practical viewpoint, these values are only hypothetical intermediate parameters which have

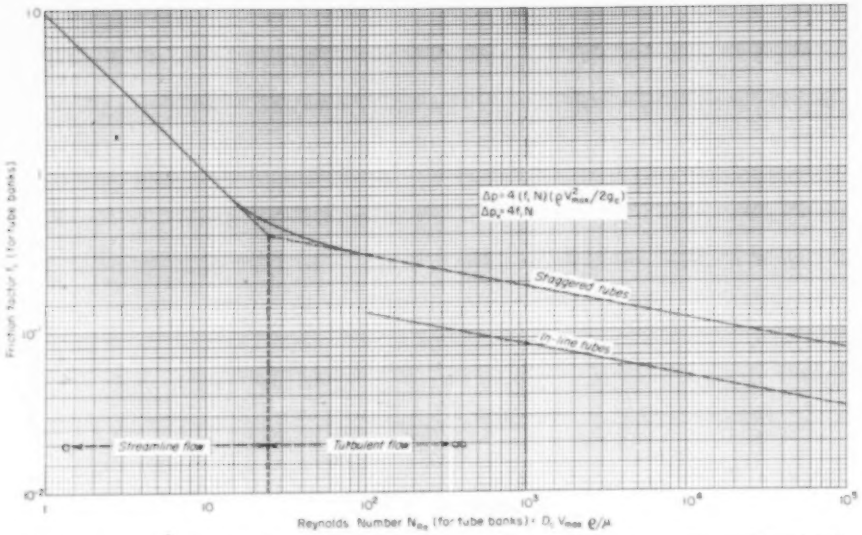
Friction factor f_t (for tube banks)
Reynolds Number N_{Re} (for tube banks) = $D_t V_{max} \rho/\mu$
$\Delta p = 4 f_t N (\rho V_{max}^2/2g_c)$
$\Delta p_r = 4 f_t N$
Staggered tubes
In-line tubes
Streamline flow
Turbulent flow

Fig. 3—Friction factor vs. special Reynolds number for flow across tube banks with average arrangement and spacing of tubes.[7]

little influence on the final result. If the refinement of using an accurate value for $(L/D)_e$ is desired—although it is rarely justified—Equation (7b) may be used with the assumed diameter to give a first approximation of D. This value can then be incorporated in a Reynolds number from which $(L/D)_e$ can be found by Fig. 2. The operation can then be repeated using the corrected value of $(L/D)_e$.

Example 2—A 1,000-ft. long horizontal pipe is to handle 100 gpm. of water at a total pressure drop of 30 psi. Calculate the required pipe size.

First, using Method (1): $q = 100/(60 \times 7.48) = 0.223$ cu. ft./sec. Then, if $\Delta p = 30 \times 144 = 4{,}320$ lb. force/sq. ft., $\rho = 62.3$ lb./cu.ft.; and $(L/D)_e$ is taken at 40: $D = (8 \times 62.3 \times 1{,}000 \times 0.223^2)^{0.5} \div (32.17^\pi \times 3.14 \times 4{,}320 \times 40)^{0.2} = 0.214$ ft. = 2.57 in. Use 3-in. pipe.

Now, using method (2): Assume 1-in. Sch. 40 pipe (1.049 in. I.D.), which has a cross section of 0.00600 sq. ft. Then $V = 0.223/0.00600 = 37.2$ ft./sec.; and the pipe velocity head (from Eq. 4) $= 62.3 \times 37.2^2/(288 \times 32.17) = 9.32$ lb./sq. in. Hence $\Delta p_r = 3.22$. From Equation (7b), assuming $(L/D)_e = 40$: $D = 1.049\ [1{,}000 \times 12/(3.22 \times 40 \times 1.049)]^{0.5} = 2.57$ in. Hence, use 3-in. Sch. 40 pipe. Even if a ridiculous diameter such as 1,000 ft. had been assumed to start with, the final answer would have come out correctly, although with greater difficulty in locating decimal points.

VALVES AND FITTINGS

When the flow is turbulent, the pressure drop through valves and fittings may be expressed as either an equivalent length of straight pipe of the same nominal size, or as a number of velocity heads lost in pipe of the same size. The two methods give slightly different results but both are accurate within the limits of available data and the structural variations of commercial valves and fittings. Equivalent length gives somewhat better results below $N_{Re} = 100{,}000$, while the equivalent velocity head is more accurate at higher N_{Re} values. Table II lists both values for the most common types of valves and fittings. The data, based on averages of data reported in the literature[7,8,9] are probably accurate to better than ± 30 percent.

Example 3—In Example (1) consider that in addition to 200 ft. of Sch. 40 pipe of 2-in. nominal diameter, the line includes 12 standard 90-deg. ells and a fully open plug disk globe valve. What is the additional pressure drop at a flow of 50 gpm. of water? From Table II the drop through the ells is $12 \times 0.74 = 8.9$ pipe velocity heads, and through the globe valve, 9.0 pipe velocity heads. The drop for valves and fittings is thus $8.9 + 9.0 = 17.9$ pipe velocity heads or $17.9 \times 0.36 = 6.4$ ft. of water and the pressure drop for the line plus valve and fittings is 9.5 + 6.4 or 15.9 ft. of water.

TUBE BANKS

Pressure drop across tube banks can be calculated similarly to drop in pipe flow, provided suitable terms are used in Equation (7). Thus, an appropriate friction factor f_t can be substituted for f, the number of rows of tubes N can be substituted for the ratio L/D, and the smallest clearance between the tubes D_t can be substituted for D. (Sometimes the outside diameter of the tube is used.) The velocity chosen is V_{max}, the maximum velocity between the tubes at the smallest free cross-section through which all the fluid must pass. The Reynolds number is then given in the form $N_{Re} = D_t V_{max} \rho/\mu$ and Equation (7) becomes

$$F = \Delta p = 4 f_t N (\rho V_{max}^2/2g_c) \qquad (10)$$

For all in-line arrangements and the staggered arrangements commonly encountered, V_{max} and D_t are based on the free area and clearance between tubes in a row normal to the general flow direction.

Reasoning again as in pipe flow, Eq. (10) becomes:

$$\Delta p_r = \Delta p/(\rho V_{max}^2/2g_c) = 4 f_t N \qquad (11)$$

where the velocity head corresponds to the previously defined maximum velocity. Evaluation of f_t can be made from Fig. 3[7] based on $N_{Re} = D_t V_{max} \rho/\mu$. The two curves in the turbulent region give average values of f_t for in-line and staggered tube arrangements, for tube spacings commonly used. More detailed data can be secured in Refs.

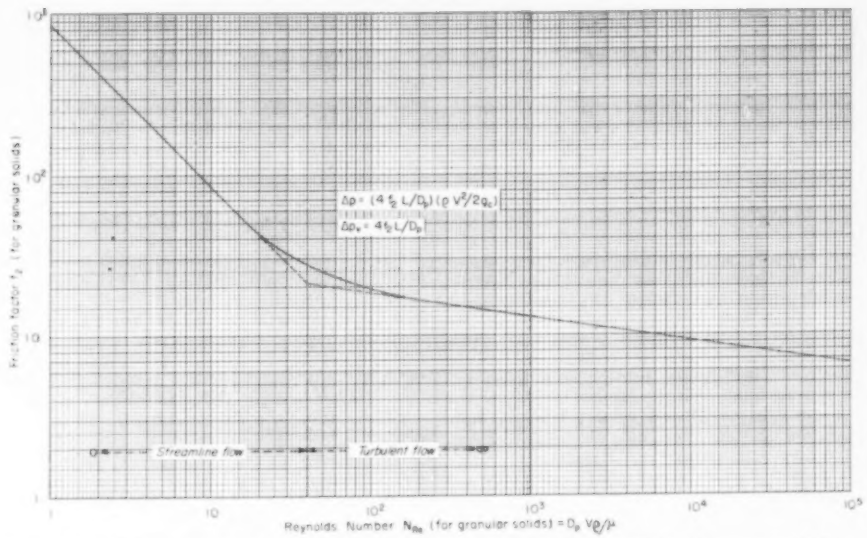
Friction factor f_s (for granular solids)
$\Delta p = (4\,f_s\,L/D_p)(\rho\,V^2/2g_c)$
$\Delta p_v = 4f_s\,L/D_p$
Streamline flow
Turbulent flow
Reynolds Number N_{Re} (for granular solids) = $D_p\,V\rho/\mu$

Fig. 4—Friction factor vs. special Reynolds number for flow through beds of granular solids with average particle shapes and degree of packing.[20]

28-32. (See also D. F. Boucher, p. 118 this issue.) The curve in the streamline region, below $N_{Re} = 25$, is presented in this way only for simplicity. It represents available data for two staggered arrangements only within ± 40 percent. A better correlation can be made on the basis of hydraulic diameter.[27]

At values of $N_{Re} = D_e V_{max}\,\rho/\mu$ greater than 100, the friction factor can be averaged with fair accuracy to give "memory" equations suitable for estimating within better than ± 50 percent in tube bank arrangements commonly encountered in practice, which are more than five rows deep. The average of f_t for staggered tubes is 0.18 and for in-line tubes, 0.08, so that Equation (11) can be rewritten for staggered tubes as:

$$\Delta p_v = 0.72\,N \tag{12}$$

and for in-line tubes as:

$$\Delta p_v = 0.32\,N \tag{13}$$

Hence each tube row gives a pressure drop of approximately 0.72 velocity heads for staggered arrangements, and 0.32 velocity heads for in-line arrangements, with V_{max} used in calculating the velocity head.

In the case of a single row of tubes, or if the tube rows should be more than five tube diameters apart, the pressure drop would be similar to that of a number of rectangular nozzles in parallel. The pressure drop to the point of minimum clearance would be 1 velocity head (as later discussion of nozzles will show), followed by a partial pressure recovery behind the tubes. The total unrecovered drop would be given by Equation (24). However, actual tube arrangements seldom use tube rows more than two pipe diameters apart and the rows therefore interact upon each other, the second row having less drop than might be expected because the fluid still retains some of the high kinetic energy gained in the first. It has been shown[20] that the pressure drop across the first row is the same for either in-line or staggered arrangements. However, in-line arrangements with close tube row spacing decrease the apparent pressure drop per row, while with some staggered arrangements, close spacing may deter pressure recovery behind the tubes and thus increase the apparent pressure drop.

Few data are available for baffled exchangers. The pressure drop across the baffles depends on the tube arrangement. Leakage between tubes and baffles may decrease the actual pressure drop to as little as one-tenth that calculated from Equations (10) to (13).[28] With tightly fitted baffles, the pressure drop around the baffle may ordinarily be taken as 2 velocity heads based on the free flow area around the baffle (see Ref. 4, p. 828).

BEDS OF GRANULAR SOLIDS

As in the case of tube banks, the pressure drop through a bed of granular solids may be expressed as a variation of Equation (7) if the values of the terms are properly chosen. (See also Max Leva, p. 115 this issue.) For this purpose we use a new Reynolds number $N_{Re} = D_p V\,\rho/\mu$ where D_p is particle diameter and V is the superficial fluid velocity over the gross cross sectional area of the bed. Then using the proper values of f_s from Fig 4[20]:

$$F = \Delta p = (4f_s L/D_p)(\rho V^2/2g_c) \tag{14}$$

$$\Delta p_v = \Delta p/(\rho V^2/2g_c) = 4f_s L/D_p \tag{15}$$

Fig. 4 gives average values of f_s for particle shapes and packing commonly encountered in practice. Actually, particle size and degree of packing do affect f_s and more accurate data are available if needed.[20-29]

Equation (15) can be simplified to

$$\Delta p_v = 60\,(L/D_p) \tag{16}$$

if an average value of 15.0 is taken for f_s. This holds to better than ± 50 percent for average packing and values of $N_{Re} = D_p V\,\rho/\mu$ of more than 80. This equation shows that for each layer of particles, a pressure drop of 60 superficial velocity heads results, which indicates that the actual minimum cross-sectional area available for flow is of the order of $1/(60)^{\frac{1}{2}}$ or 13 percent of the over-all cross-section of the bed. Since analysis shows percentages of 9 and 21 for the minimum flow cross-section in beds packed with uniform spheres in triangular and rectangular arrangement respectively, it appears that the drop through each

layer can be visualized as about 1 velocity head based on the actual minimum flow area between particles.

EXPANSIONS AND CONTRACTIONS

Friction losses for abrupt expansion or contraction are independent of the Reynolds number and depend on the ratio of areas of the smaller to the larger flow passage. From a momentum balance the friction loss for an abrupt expansion, expressed as a number of velocity heads in the smaller (upstream) cross-section is:

$$F_e = (1 - \alpha)^2 \tag{17}$$

where α is the ratio of the smaller (upstream) to the larger (downstream) cross-section. It is evident that for expansion into a very large chamber (α approximately 0) the friction loss will be 1 velocity head. However, the pressure drop for infinite expansion is zero since (from Bernoulli's theorem, Equation 1) pressure drop is the algebraic sum of the difference between downstream and upstream velocity heads, and the friction loss. Since the friction loss will be less than 1 velocity head for finite expansions, the pressure drop will be negative, which means that a pressure recovery is obtained.

With an abrupt inlet, experimental constants are needed. Here friction loss is given by:

$$F_c = K_1 (K_2 - \alpha) \tag{18}$$

in which α is again the ratio of the smaller flow area (now downstream) to the larger (upstream), and F_c is the number of velocity heads in the smaller cross-section. The constants K_1 and K_2 are given in the table of nomenclature. The loss at such an inlet is due largely to stream contraction within the inlet and it is partially recovered downstream. The constants reflect this fact. Thus for abrupt inlet from a relatively large chamber, the friction loss is 0.5 velocity heads and the change in kinetic energy is 1 velocity head, based on downstream velocity, so that the total pressure drop is 1.5 velocity heads. For an abrupt inlet from a smaller chamber, the drop will be less.

DIFFERENTIAL HEAD METERS

Head type meters, which include the pitot tube, nozzle, venturi and orifice, measure a differential head which is related to the flow rate by a discharge coefficient C. The differential heads produced by such meters can be expressed variously, including a certain number of velocity heads.

Pitot Tube—Although the pitot tube measures a form of differential head (consisting of the difference between the sum of the static and velocity heads applied to the impact tube, and the static head applied to the static holes), it is the only one of the head meters which measures the velocity head directly. Since it measures the local velocity at the point where the instrument is situated, and not the average velocity as the other head meters do, either the relation of average to local velocity must be known, or a traverse of the pipe must be made.

The equation for calculating local velocity from a pitot tube reading is commonly given as:

$$V = C \sqrt{2g_c \, \Delta p / \rho} \tag{19}$$

where the discharge coefficient C is substantially unity for the standard single-bend pitot. For the double long-bend type, experimental data indicate $C = 0.855$, since the static tube records the static pressure minus a suction effect dependent on the kinetic energy of the fluid. In this equation Δp is the differential reading obtained. Rewriting to express Δp as a number of velocity heads:

$$\Delta p_v = \Delta p / (\rho V^2 / 2g_c) = 1/C^2 \tag{20}$$

For the ordinary pitot tube the number of velocity heads indicated is 1, while for the double long-bend type, it is $1/(0.855)^2 = 1.37$, showing that the suction effect mentioned is 0.37 velocity head.

Nozzles and Venturis—Nozzles, venturis and orifices all operate on the same principles and, in fact, all employ the same equations when the experimental coefficient C is properly chosen. The differential head Δp, between an upstream pressure tap and the point of smallest flow cross-section (throat in nozzles or venturis, and vena contracta in orifices), is related to the average fluid velocity at the throat or orifice by the expression:

$$V = C \sqrt{2g_c \, (\Delta p / \rho) / (1 - \alpha^2)} \tag{21}$$

where α is the ratio of throat or orifice area to pipe area and C is a discharge coefficient. The equation is identical to that for the pitot tube except for the introduction of the velocity-of-approach correction $(1 - \alpha^2)$. Rewritten:

$$\Delta p_v = \Delta p / (\rho V^2 / 2g_c) = (1 - \alpha^2)/C^2 \tag{22}$$

where Δp_v is the differential in velocity heads based on the throat or orifice area. Expressed in terms of pipe velocity head, the equation is

$$\Delta p_v = (1 - \alpha^2)/\alpha^2 C^2 \tag{23}$$

Such meters operate by converting pressure energy to velocity energy by reason of acceleration. The differential measures the increase in velocity head from pipe to throat, plus any friction loss during the acceleration. In venturis and nozzles the coefficient C is 0.98-0.99 for pipe Reynolds numbers above 10,000. Therefore, Equation (22) indicates that the differential head for throat areas small compared with the pipe is substantially 1 throat velocity head. This differential is greater than 1 throat velocity head by only 2 to 4 percent, due to friction losses. For larger throat areas the differential is reduced by 1 pipe or approach velocity head as provided by means of the term $(1 - \alpha^2)$.

Orifices—What has been said about nozzles and venturis applies equally to sharp-edged orifice meters except that a different value of C must be used in Equations (21), (22) and (23) when V is the velocity based on orifice area. Although C varies with the ratio of orifice to pipe diameter, for pipe Reynolds numbers greater than 10,000 and ratios of orifice to pipe diameter less than 0.8, the coefficient C will be substantially 0.61 for vena contracta taps. Since the vena contracta is the point of greatest stream contraction, and hence of greatest fluid velocity, other coefficients must be used for pipe or flange taps.

The orifice employs a lower discharge coefficient than the venturi or nozzle, not because it is a less efficient device as is generally supposed, but because the fluid stream contracts to an area less than that of the orifice at the vena contracta. In both nozzle and venturi calculations the throat area is actually the minimum flow area, but with sharp-edged orifices, the differential represents the difference in velocity head at the upstream tap and at the vena contracta, whereas the equation assumes that the minimum area is that of the orifice. Therefore C must incorporate two factors, one to allow for friction losses and the other to compensate for stream contraction. If the equation used vena contracta area, C would be 0.99 or practically the same as the nozzle, corresponding to a friction loss of about 2 percent of the differential head. Since the vena contracta area is not used in the equation, but is about 62 percent of the orifice area, the effective coefficient must be approximately 0.99×0.62 or 0.61. An orifice therefore behaves like a nozzle with a throat area 62 percent that of the orifice.

When the velocity-of-approach correction is negligible, i.e., for orifice to pipe diameter ratios of less than 0.3, the differential head for vena contracta taps is approximately 1 velocity head based on the vena contracta area, or 2.7 velocity heads based on the orifice area.

Not all of the pressure drop occurring in a nozzle or orifice is lost, a substantial part being recovered within a distance of four pipe diameters downstream. The unrecovered pressure drop, which corresponds to the differential for a nozzle or orifice with pipe taps, can be calculated from a momentum balance and is closely approximated as a number of pipe velocity heads by:

$$\Delta p_v = \left[\sqrt{\frac{1 + \alpha^2 C^2 - \alpha^2}{\alpha^2 C^2}} - 1 \right] \quad (24)$$

where C is 0.99 for a nozzle and 0.61 for an orifice, and α is the ratio of nozzle or orifice area to pipe area. Equation (24) shows that the overall unrecovered pressure drop will be the same for a nozzle and an orifice having the same differential, that is, for a nozzle diameter 62 percent of that of the orifice.

Example 4—Air at substantially atmospheric pressure and 20 deg. C. is flowing through a 20-in. diameter duct. When measured with a 10-in. diameter standard sharp-edged orifice using vena contracta taps, the differential pressure is 3.5 in. of water. What is the flow rate? By Equation (22), the orifice differential in velocity heads based on orifice area is $(1 - \alpha^2) \cdot C^2$, where α is $(10/20)^2$ and C can be taken as 0.61. The differential is then $(1 - 0.25^2) / 0.61^2 = 2.52$ orifice velocity heads. Therefore, the velocity head based on the orifice area is $3.5/2.52 = 1.39$ in. of water. Using Fig. 1, the velocity based on the orifice area is 78.4 ft./sec. Since the orifice area is $(\pi/4)\ (10/12)^2 = 0.545$ sq. ft., air flow is $0.545 \times 78.4 \times 60 = 2,560$ cfm.

ESTIMATING WITHOUT DATA

Through the use of the method of visualizing flow patterns and mechanisms discussed here, and the concept of pressure drop and friction loss in terms of velocity head, it is often possible to make pressure drop estimates within ± 50 percent, even when no experimental data are at hand. By visualizing the type of turbulent flow pattern that is apt to occur, reasonable estimates can be reached by analyzing how losses will take place and by estimating the number of velocity heads that will be lost. Two examples will help to make these estimating methods clear.

A 90-deg. ell is formed by welding together two equal intersecting cylinders. It is expected that the fluid will lose its initial kinetic energy by impact in the square bend and that the energy to carry the fluid out of the bend must come from the pressure energy of the fluid. Thus the friction loss (and pressure drop) would be estimated at 1 velocity head. That the estimate is reasonable is indicated by the loss of 1.3 velocity heads for the square 90-deg. screwed fitting listed in Table II. Expansion and contraction losses in screwed fittings account largely for the extra 0.3 velocity head loss.

A flow distributor consists of a plate containing a sharp-edged orifice of diameter D_o. Fluid passing through the orifice impinges on a backing plate parallel to the first plate and separated from it by a distance x, then flows radially outward between the plates. If the orifice plate is thin compared to the hole diameter, a vena contracta will be formed as with a sharp-edged orifice, provided the backing plate is not so close as to prevent full contraction before impingment takes place. At first glance it might seem difficult to estimate the pressure drop for such an arrangement, but the analysis given below predicted the result within ± 10 percent as was shown later by actual test data covering a wide range of conditions and dimensions.

Here it would be expected that substantially all of the kinetic energy represented by the velocity head corresponding to the vena contracta area would be lost by impingement on the backing plate, and that this loss would be 1 velocity head based on the vena contracta, or 2.7 velocity heads based on the orifice area (see orifices, above). Additional velocity energy for radial flow after impingement must then be developed by conversion of part of the fluid's pressure energy. Since radial flow will take place through the cylindrical area $\pi x D_o$ between the plates at the orifice, then the additional velocity energy will correspond to 1 velocity head based on this area. And since the radial expansion from the orifice is relatively abrupt, this kinetic energy will be largely dissipated as heat by turbulence. Therefore the over-all drop through the orifice and into the space between the plates will be the sum of the velocity heads corresponding to the vena contracta (or 2.7 velocity heads corresponding to the orifice area), and the circular area $\pi x D_o$. Based on the orifice area the drop in velocity heads will be

$$\Delta p_v = 2.7 + 1.0\ [\pi D_o^2 / 4)\ / (\pi x D_o^2)]^2 = 2.7 + (D_o / 4x)^2.$$

In these examples the flow pattern and mechanism have possibly been oversimplified to facilitate the pressure drop estimate. For example, in the case of the flow distributor there may be some kinetic energy recovery following impact and there must be some contraction as the fluid flows radially away from the orifice. However, the two effects tend to offset each other so far as their influence on total pressure drop is concerned. Furthermore, if the plate space x should be small compared to the orifice diameter, the contraction of the jet may not be completed before impingement, but any error here would be but a small portion of the over-all pressure drop. The close correspondence between estimate and experiment may be due in part to compensating errors so it is well to make due allowance with safety factors in estimates of this character. Their magnitude will vary depending on the type of problem, but an idea of this magnitude can be obtained by considering the possible extreme flow patterns.

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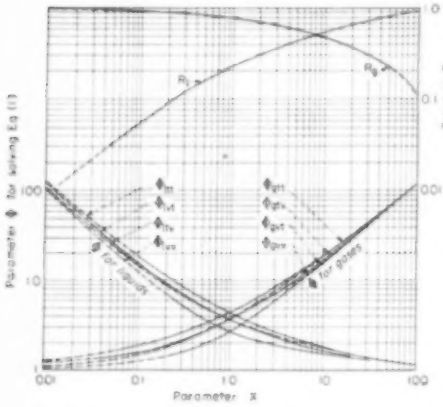

Fig. 1—Generalized curves for determining parameter ϕ and fraction R from two-phase flow modulus X.[1]

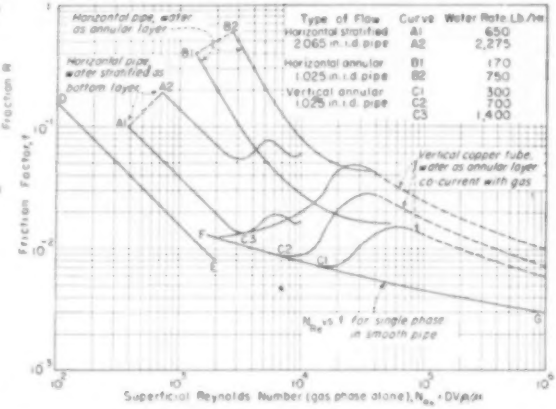
Horizontal pipe, water as annular layer
Horizontal pipe, water stratified as bottom layer
Type of Flow | Curve | Water Rate Lb./hr.
Horizontal stratified, 2.065 in. i.d. pipe | A1 | 650
A2 | 2,275
Horizontal annular, 1.025 in. i.d. pipe | B1 | 170
B2 | 750
Vertical annular, 1.025 in. i.d. pipe | C1 | 300
C2 | 700
C3 | 1,400
Vertical copper tube, water as annular layer co-current with gas
N_{Re} vs. f for single phase in smooth pipe
Friction Factor, f
Superficial Reynolds Number (gas phase alone), N_{Re_g}

Fig. 2—Friction factors for two-phase flow of water and air, based on "superficial" Reynolds number.

Flow of Gas-Liquid Mixtures

Much more complex than single-phase flow, gas-liquid flow has not yet yielded readily usable data

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During the past ten years there has been considerable research on the simultaneous flow of gases and liquids, but the published results, thus far, have not been in a form easily applicable to industrial calculations. This lack of usable correlations probably comes from the fact that the field of gas-liquid flow is large and rather poorly defined, both with regard to the mechanics of flow and to the technical applications. At present perhaps the best that can be done to summarize progress in this field is to outline the scope of gas-liquid flow, to review the present correlations, inadequate though they may be, and to indicate what may be expected in future developments.

The field of gas-liquid flow can be divided roughly into flow with exchange of mass between phases, and flow without such exchange. One example of flow without mass exchange is the air or gas lift, where an inert gas is used to move a liquid. A case more pertinent to chemical engineering is the flow of mixtures through reactor tubes when an inert gas has been added as a diluent. Two-phase flow without mass exchange is the easiest type to study experimentally and has accounted for most of the available data. Gas-liquid flow accompanied by exchange of mass between phases is commonly encountered during evaporation, condensation, and chemical reactions involving gaseous reactants or products. In these cases the friction loss changes continually as the gas-liquid ratio changes and the solution in general becomes a point-to-point calculation along the path of flow. Experimental data for these cases have thus far proved too complicated for analysis although a start in this direction has been made.[2, 10]

In gas-liquid two-phase flow, we find there are four possible combinations of viscous and turbulent flow conditions. In addition, there is a mobile boundary between phases so that the shape of the flow channel may change for each phase and the roughness of the channel may vary as interfacial waves form. Two-phase flow does not generally occur as a foam or successive slugs of liquid and gas, as is often thought to be the case. Instead, the cross-section of each phase changes in a regular manner with changes in flow rate and fluid properties, and at least five distinct types of flow have been reported by numerous observers. In order to explore the possible types of flow, let us assume a horizontal pipe running full of liquid and consider the effect of adding increasing amounts of gas. The types of flow which successively occur are:

1. *Bubble flow* in which separate bubbles of gas move

along the top of the pipe at approximately the same velocity as the liquid.

2. *Stratified flow* in which the liquid flows along the bottom of the pipe and the gas flows above, over a smooth interface.

3. *Wave flow*, which is similar to stratified flow except that the gas moves at a higher velocity and the interface is disturbed by waves.

4. *Slugging flow* in which the level of the interface rises and falls, and frothy slugs pass periodically along the pipe at a much greater velocity than the average liquid velocity.

5. *Annular flow* in which the liquid flows in a film around the pipe wall and the gas flows at high velocity through the central core.

The transition from one type to another is not abrupt. This is true particularly for the transition from slugging to annular flow where, as the gas velocity increases, the slugs increase in frequency and decrease in intensity, the liquid film creeps up the sides of the pipe, and finally a thin film reaches the top. As the gas velocity is further increased the liquid film thickens at the top of the pipe and a more uniform annulus is formed. A certain amount of spray or entrainment is carried in the gas stream throughout the regions of slugging and annular flow, but no data are available on the proportion of liquid so carried.

For the case of co-current flow in vertical tubes, bubble, slugging, and annular flow occur during upward motion but only slugging and annular flow occur during downward flow. When countercurrent flow of gas and liquid is considered, the possible types of flow are even more limited because bubble flow is not possible in a horizontal tube, and annular flow is only possible at low gas velocities in a vertical tube. Countercurrent flow is governed by the available hydraulic gradient and must take place under this rather rigid limitation. Few data are available for countercurrent flow and no correlations have been proposed.

METHODS OF CORRELATION

With such a variety of types of flow it is small wonder that no general method has been devised for determining transition points or friction losses. Moreover, since each type of flow involves more than twice as many variables as are required to describe single-phase flow, any correlation might be expected to be complex. There has indeed been only one general correlation proposed for determining pressure drop during co-current two-phase flow. This correlation, presented by Martinelli and co-workers[1], is based upon the assumption that: (1) The pressure drop for the gas phase, the liquid phase, and the two phases are all equal during two-phase flow. (2) The gas volume plus liquid volume at any instant must equal the volume of the pipe.

Their equations were complex algebraically and so were simplified by the introduction of the parameters ϕ and X, which are defined by Equations (1) and (2):

$$\phi_{tt\,or\,L} = \sqrt{\left(\frac{\Delta P}{\Delta L}\right)_{TP} \div \left(\frac{\Delta P}{\Delta L}\right)_{or\,L}} \qquad (1)$$

$$X = \sqrt{\frac{N_{Re(tt)}{}^{n}}{N_{Re(t)}{}^{n}} \frac{C_L}{C_G} \left(\frac{W_L}{W_G}\right)^2 \frac{\rho_G}{\rho_L}} = \sqrt{\frac{(\Delta P/\Delta L)_L}{(\Delta P/\Delta L)_G}} \qquad (2)$$

Here $(\Delta P/\Delta L)_{TP}$ is the pressure gradient during two-phase flow, $(\Delta P/\Delta L)_L$ is the pressure gradient during liquid-phase flow and $(\Delta P/\Delta L)_G$ is the pressure gradient during gas-phase flow. The assumption was made that all unknowns in the basic equation are functions of X and so the parameter ϕ can be expressed as a function of X alone. The constants for use in Eq. (2) are given in the accompanying table.

For a given set of flow conditions, X was calculated and the corresponding ϕ was determined by experiment. From this the generalized plot of X vs. ϕ given in Fig. 1 was then prepared. Fig. 1 also carries experimentally determined parameters R_L and R_G which are the fractions of the tube occupied by each phase. These factors also are assumed to be functions of X alone.

Procedure for using this correlation is as follows:*

1. Calculate a fictitious Reynolds number for each phase by considering it to be flowing alone in the pipe. From Table I determine the arbitrarily defined type of flow from these Reynolds numbers. For example if the liquid Reynolds number $N_{Re(L)}$ is less than 1,000 and the gas Reynolds number $N_{Re(G)}$ is greater than 2,000, the flow is classed as "vt"—that is, liquid viscous, gas turbulent.

2. Knowing the type of flow, select the corresponding values of n, m, C_L and C_G from the table.

3. Calculate X using these values in Eq. (2), noting that $(\Delta P/\Delta L)_{L\,or\,G}$ is the calculated pressure gradient which would occur if the pipe were full of the gas or liquid alone. In effect, the pressure gradient is calculated for the liquid alone, then for the gas alone, and finally the two gradients are used to determine X.

4. From Fig. 1 obtain the value of ϕ corresponding to the calculated X and the type of flow (vt) under considera-

Table I—Exponents and Constants for Various Types of Flow

	Liquid Turbulent Gas Turbulent	Liquid Viscous Gas Turbulent	Liquid Turbulent Gas Viscous	Liquid Viscous Gas Viscous
Quantity	(tt)	(vt)	(tv)	(vv)
n	0.2	1.0	0.2	1.0
m	0.2	0.2	1.0	1.0
C_L	0.046*	16	0.046*	16
C_G	0.046*	0.046*	16	16
$N_{Re(L)}$	>2,000	<1,000	>2,000	<1,000
$N_{Re(G)}$	>2,000	>2,000	<1,000	<1,000

* For smooth pipes.

* The ϕ-X correlation is based on data for the flow of mixtures containing air as the gas and water, benzene, and several hydrocarbon oils as the liquids. Glass capillary tubes, 1.017 in. glass pipe, and 0.622 in. galvanized iron pipe were used. The authors' experimental data fall within a range of ±40 percent of the final correlating curves and the experimental data of Jenkins[2] for turbulent flow in a 1-in. copper tube also fall within this range, which can be considered the general accuracy of the correlation in the region of turbulent flow. For stratified flow in horizontal tubes the correlation predicts pressure drops up to 100 percent above available experimental results. Stratified flow, however, is rare in commercial practice and the predicted pressure drop is on the conservative side. Admittedly, some factors are not covered by the correlation. Interfacial roughness is not directly included, although its possible effect has been recognized, and recent work at the University of Delaware[3] has indicated that this factor appreciably increases the turbulence and therefore the pressure drop in the gas phase. Additional data are needed to identify and include factors which will improve the correlation.

NOMENCLATURE

- C = A constant.
- D = Diameter, ft.
- G = Total mass velocity, lb./(sec.) (sq. ft.).
- g_c = Conversion factor, (lb. mass/lb. force) (ft./sec.²).
- L = Length, ft.
- m,n = Constants.
- P = Pressure, lb. force/sq. ft.
- R = Fraction of tube filled with one phase, dimensionless.
- v = Specific volume, cu. ft./lb.
- W = Mass rate of flow, lb./sec.
- X = Two phase flow modulus.
- ρ = Fluid density, lb./cu. ft.
- ϕ = Function of X used in calculating two-phase pressure drop.

SUBSCRIPTS

- G = Gas phase flowing alone.
- L = Liquid phase flowing alone.
- TP = Two-phase flow.
- v* = Viscous flow.
- t* = Turbulent flow.

* When used together, e.g., (vt), the first subscript refers to the liquid.

tion. Use the ϕ_l set of curves when it is desired to use $(\Delta P/\Delta L)_l$ in the denominator of Eq. (1), and use the ϕ_g set when $(\Delta P/\Delta L)_g$ is to be used.

5. Calculate the two-phase pressure drop by substituting the value for ϕ and the appropriate single-phase pressure drop in Eq. (1).

6. The fraction of the pipe volume filled by each phase can be read directly from the R curves of Fig. 1 at the calculated value of X.

While the ϕX correlation is the best available method for calculating gas-liquid pressure drop, it does not permit direct comparison with single-phase data nor does it indicate the limits for stratified, wave, or annular flow. In order to illustrate some of these points, data for the flow of water-air mixtures are presented on the usual friction factor plot in Fig. 2. The friction factor and Reynolds numbers are "superficial" in the sense that they are calculated for the gas phase as though the gas were flowing alone in the pipe. The effect of the liquid phase is shown as deviations from the single-phase curve *D E F G*, which is the accepted curve for flow of a single phase through a smooth pipe. In this case it represents the flow of air alone.

The family of curves lying between *A*1 and *A*2 represents increasing amounts of water flowing as a layer along the bottom of a horizontal brass pipe. Friction factors increase with increased water rate at any gas Reynolds number. In the region of viscous flow the friction factor lines are displaced upward in the usual manner for unsymmetrical channels. At a superficial gas Reynolds number of about 3,000 the gas phase become turbulent and the friction factor rises sharply during the transition region. In the turbulent region the friction factor decreases until the superficial Reynolds number reaches 8,000 to 10,000 after which the friction factor again rises rapidly. This second rise is due to wave formation at the interface and is analogous to the rise in the friction factor due to roughness inside pipes. Soon after wave formation, the region of slugging begins and accurate pressure measurement becomes impossible.

Between *B*1 and *B*2 another family of curves represents flow in a horizontal copper tube. The water is introduced through an annular nozzle. The higher pressure drop in the viscous region is probably due to entrance effects, because steady annular flow is not normal at these flow rates. These curves are of particular interest in the turbulent region where true annular flow may exist. At superficial Reynolds numbers of from 20,000 to 50,000 the curves pass through a horizontal zone and then again decrease with increasing Reynolds numbers.

The C_1, C_2, and C_3 curves represent downward flow in a vertical copper tube with water flowing down the inner wall of the tube. While no data are available in the region of viscous flow, the falling film should aid the gas flow and result in friction factors near those for single-phase flow. In the low turbulent region this condition also appears to be fulfilled, but at higher superficial Reynolds numbers the friction factors rise sharply to a maximum value. Data are not available to show what happens after the maximum but by analogy to the *B* curves, both sets of curves are extrapolated with a negative slope in such a manner that they become roughly parallel to the curve for single-phase flow. This extrapolation implies that the water layer imparts "wavy roughness" characteristics to the gas flow.

Conclusions worth noting from Fig. 2 are: (1) For a given gas flow the addition of small amounts of liquid phase may increase the pressure drop from 2 to 50 times. (2) The orientation of the tube is not important at high gas velocities. (3) The liquid phase imparts a "roughness" will effect at high velocities.

TWO-PHASE FLOW APPLICATIONS

Gas Lifts—For the case of gas lifts there are articles by Babson,[1] Gosline[2] and Shaw[15] covering some of the practical aspects, and an excellent theoretical analysis by Hershey.[3] No general correlation is presented but isothermal efficiencies are reported in the range of 20 to 30 per cent and general rules are given for eductor pipe submergence.

Flashing Liquids—When a saturated liquid flows through a pipeline, a portion of the liquid flashes into vapor as the pressure decreases. By using the continuity equation with the general energy equation:

$$\Delta L = \frac{D}{2f}\left[\left(\frac{g_c}{G^2}\right)\left(\frac{\Delta P}{v_{av}}\right) - \frac{\Delta v}{v_{av}}\right] \qquad (3)$$

This equation may be evaluated numerically if, as an approximation, the process is assumed to take place at constant enthalpy and the enthalpy of the entering liquid is used throughout the calculations. Increments of pressure are taken and the average specific volume and the difference in specific volume for the increment are obtained. An average value of 0.003 is taken for the friction factor f based on the data of Bottomly[3] and Benjamin and Miller.[4] The increment of length for the increment of pressure can then be calculated for a given pipe diameter and the summation of these increments is the length of pipe for a given pressure drop.

Boiling Liquids—Davidson et al.[5] have presented data for water boiling at high pressures during flow through boiler tubes and Martinelli and Nelson[12] have applied the ϕX correlation to the data. A method for determining the pressure drop for oil-vapor mixtures flowing through furnace coils is presented by Dittus and Hildebrand.[6] In the chemical industries the use of jacketed pipe evaporators, either as a single straight pipe or as a series of S-bends, has been found useful for solvent removal or steam stripping. McAdams et al.[13, 14] have presented data on the vaporization of water and benzene flowing through such jacketed pipes.

Condensation—The curves C_1, C_2, and C_3 of Fig. 2 have been used by Carpenter[4] as the basis for calculating the pressure drop accompanying high gas velocity during condensation inside tubes. The method suggests a possible approach to condenser pressure drop calculations.

In conclusion, there is need for experimental data on mixtures other than air and water. It seems unlikely that any general correlation can be applied to all types of gas-liquid flow. However, there is activity in both industrial and University research in this field, and in the next few years considerable new information should be obtained which may result in usable correlations for some, if not all, of the types of flow.

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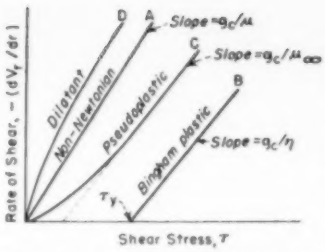

Fig. 1—Shear diagrams for Newtonian and non-Newtonian suspensions, several types.

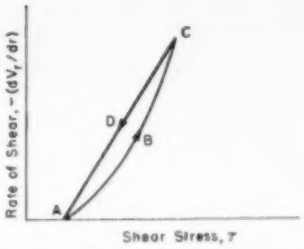

Fig. 2—Shear diagram for a thixotropic suspension showing "hysteresis loop."

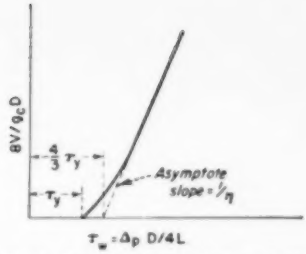

Fig. 3—Shear diagram of Bingham plastic flow in a cylindrical pipe.

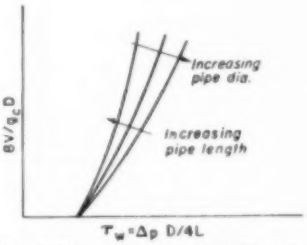

Fig. 4—Shear diagram of thixotropic suspension affected by pipe dimensions.

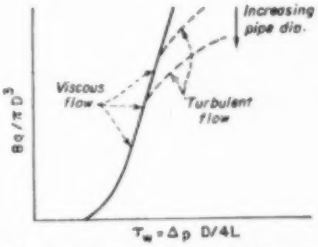

Fig. 5—Bingham plastic in cylindrical pipe shows branches in turbulent region.

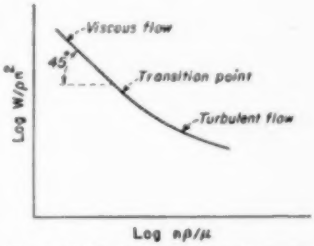

Fig. 6—Calibration curve for a viscometer of the Stormer type.

Flow of Non-Newtonian Suspensions

Solid-liquid suspensions, many of them important in chemical engineering, do not follow the simple laws of flow

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Flow of solid-liquid suspensions in pipelines is a very important field of chemical engineering fluid flow. Some examples are water suspensions or slurries of sand, paper pulp, sewage sludge, coating clays, and drilling muds.

Some of the problems met in the transportation of suspensions are sizing of pipelines, predicting the pressure drop due to friction, and selection of pumps. The usual methods available for the solution of the above problems for the flow of simple or Newtonian fluids such as water, oil, and air do not apply to non-Newtonian suspensions because the viscosity of a non-Newtonian suspension is not constant but is a function of pipe size, solids content, and velocity. Thus, special methods and experimental data are required to solve the above problems. Much progress has been made during the past 10 years in studying the behavior of non-Newtonian suspensions.

Suspensions or slurries of solids in liquids are classified according to the general type of functional dependence of the shear stress on the rate of shear; that is, according to the general type of shear diagram. The shear diagram is a plot of the rate of shear vs. the shear stress. There are two main classifications: (*a*) Newtonian and (*b*) non-Newtonian.

(*a*) Newtonian or simple suspensions are characterized by a shear diagram given as Curve (*A*), Fig. 1. The curve is a straight line commencing at the origin; that is, the rate of shear is directly proportional to the shear stress. The inverse slope of the line is the viscosity μ, a constant. The term g_c is a conversion factor used so that the units may be consistent with practice. The definition of a Newtonian suspension, expressed mathematically, is:

$$\mu = g_c \tau / (-dV_x/dr) \qquad (1)$$

Weltmann[2] has shown experimentally that several oils behaving as Newtonian fluids at low shear stresses exhibit non-Newtonian behavior above a limiting shear stress.

(*b*) Non-Newtonian suspensions in viscous flow have a variable viscosity, dependent upon the rate of shear and, in some cases, upon the duration or period of shear. These suspensions are subdivided into five general types: (1) Bingham plastic; (2) pseudoplastic; (3) dilatant; (4) thixotropic; and (5) rheopectic.

1. Bingham plastics have a shear diagram as shown in Curve (*B*), Fig. 1. The curve consists of a straight line with a positive intercept on the shear stress axis. This intercept is called the "yield stress" τ_y. The inverse slope of the curve is the "coefficient of rigidity" η. In practice, where the shear diagram is obtained from pipe-line data or from some types of rotational viscometers, the lower portion of the curve bends toward the rate-of-shear axis as shown in Fig. 3. Curve (*B*), Fig. 1, is based on point values, whereas Fig. 3 is based on the values integrated across the pipe diameter. Some examples of Bingham plastics are sewage sludge[3] and grain suspensions in water[4]

2. *Pseudoplastics* have a shear diagram similar to Curve (*C*), Fig. 1. The curve commences at the origin and approaches a straight line at high shear stresses. The apparent viscosity decreases with increasing shear stress. The inverse slope of the straight line is called the limiting viscosity at infinite shear μ_∞. An explanation of pseudoplasticity has been given by Green and Weltmann[4]. Some lime-water slurries are pseudoplastic.

3. *Dilatant* suspensions produce a shear diagram as indicated by Curve (*D*), Fig. 1. The apparent viscosity increases with increasing shear stress. A theory for dilatancy was advanced by Reynolds.[5, 9, 10] Some examples of dilatant suspensions are: starch suspensions in water, mica suspensions in water, quicksand, and beach sand.

4. *Thixotropic* suspensions possess a structure the breakdown of which is a function of time as well as of the rate of shear. The structure can rebuild itself, if not prevented from doing so by externally applied forces. There are many explanations and theories for thixotropy.[5, 10, 11, 12, 13, 14] Fig. 2 illustrates the type of shear diagram for a thixotropic suspension obtained with a rotational viscometer. The curve *ABCD* is called the "double-consistency curve" or "hysteresis loop"; curve *ABC* being the "up-curve" and curve *CDA* is the "down-curve." The area within the loop is an indication of the amount of thixotropy—a large loop indicating considerable thixotropy and no loop indicating no thixotropy.[5, 6, 7, 9] Some examples of thixotropic fluids and suspensions are: milk, mayonnaise, greases, drilling muds, paints, inks, and gypsum in water.

5. *Rheopectic* suspensions are certain thixotropic suspensions which, upon being rhythmically shaken or tapped, will "set" or build-up (increase in apparent viscosity) very rapidly. No fully satisfactory explanation has been given for this phenomenon. Some examples of theopectic suspensions are: gypsum suspensions in water, bentonite sols, and vanadium pentoxide sols.

Viscous Flow

For the viscous flow of non-Newtonian suspensions in pipelines the pressure drop due to friction in the pipelines may be determined, or the pipe sized, from Poiseuille's equation by using the apparent viscosity μ_a, of the suspension. Here:

$$\Delta p = 32\mu_a L V/g_c D^2 \qquad (2)$$

The question is how to determine the apparent viscosity as it may be a function of the velocity, pressure drop, and pipe dimensions.

The mathematical analysis of the viscous flow of a Bingham plastic in a circular pipe was presented by Bingham.[8] The results of the analysis are as follows:

$$8\,V/g_c\,D = 1/\eta\,(\tau_w - 4/3\,\tau_y) \qquad (3)$$

$$\mu_a = g_c \tau_y\, D/6\,V + \eta \qquad (4)$$

Fig. 3 shows the shear diagram for the viscous flow of a Bingham plastic in a circular pipe. The equation of the asymptote is given by Equation (3) and the inverse slope of the asymptote is the "coefficient of rigidity" η. The "yield stress" is τ_y. The apparent viscosity in the general case is the inverse slope of a line joining the origin and a point on the curve, Fig. 3, corresponding to the shear stress in question. For the straight-line portion of the curve, the apparent viscosity is given by Equation (4). Note that the rate of shear is proportional to $8V/g_cD$; the term g_c being used so that the inverse slope will be given in convenient units for viscosity.

A shear diagram of the type shown in Fig. 3 can be obtained with capillary tubes or pipes.[8, 9] The apparatus, called a "pipeline viscometer," consists of a known length of pipe with either a blow-case or a pump to force the suspension through the pipe. The pressure drop across the pipe is measured for various rates of flow. Several known pipe sizes are used in order to determine the scale-up factor, if any, and also to determine if thixotropy exists. If the suspension is thixotropic, a blow-case is preferable because a pump (gear or centrifugal) will "break down" the suspension before it flows through the pipe.

The shear diagram may be prepared by two methods. The method shown in Fig. 3 is used for convenience in obtaining the yield stress, coefficient of rigidity, and apparent viscosity. A single curve is obtained for all pipe sizes unless the suspension is thixotropic or a scale-up factor exists. If the suspension is thixotropic, a single curve is not obtained and a scale-up factor must be used in designing a plant-size pipeline. Fig. 4 shows the shear diagram for a thixotropic suspension. From it the effect of increasing pipe diameter or pipe length may be seen.

Another convenient method of plotting pipeline data is shown by Fig. 5, in which the solid portion represents viscous flow. (The dotted turbulent flow portion will be discussed later.) In this form the curve may be used directly to size plant lines, providing the suspension is not thixotropic. For example, knowing the flow rate, pipe length, and maximum allowable pressure drop for a plant line, the diameter can be obtained by a simple "cut-and-try" method from the curve.

A mathematical theory of pseudoplastic viscous flow has been presented by Williamson[15, 16]; however, the method of plotting and applying the pipeline viscometer data as shown in Fig. 5 is applicable to pseudoplastic suspensions.

It should be emphasized that this discussion applies only to viscous flow. The flow is considered viscous if the Reynolds number is below 2,100, the same limiting value as that for simple or Newtonian fluids. The Reynolds number for a suspension is:

$$N_{Re} = V D \rho_m / \mu_a \qquad (5)$$

In large pipelines, the rate of shear does not have to be very high nor the shear stress large to have turbulent flow.

Turbulent Flow

In general, non-Newtonian suspensions behave in the turbulent flow region as Newtonian fluids. That is, the apparent viscosity is constant for a non-Newtonian suspension in turbulent flow.

The shear diagram for the turbulent flow of a Bingham plastic is shown by the dotted branching portion in Fig. 5. (The lower solid part of the curve is for viscous

Nomenclature

D	= Inside diameter of tube or pipe, ft.
f	= Fanning friction factor, dimensionless.
g_c	= Conversion factor, 32.17 (lb.) (ft.) / (lb. force) (sec.^{2})
L	= Length of tube or pipe, ft.
N_{Re}	= Reynolds number defined in text, dimensionless.
n	= Rotational speed of Stormer viscometer, rpm.
Δp	= Pressure drop, lb. force/sq. ft.
q	= Rate of flow, cu. ft./sec.
r	= A radius, ft.
V	= Velocity, ft./sec.
V_r	= Velocity at radius r, ft./sec.
$-(dV_r/dr)$	= Rate of shear, 1/sec.
W	= Stormer viscometer actuating weight, grams.
η	= Coefficient of rigidity, lb./(sec. ft.)
μ	= Absolute viscosity, lb./(sec. ft.)
μ_a	= Apparent or effective viscosity, lb./(sec. ft.)
μ_T	= Turbulent viscosity, lb./(sec. ft.)
μ_∞	= Apparent or limiting viscosity at infinite shear, lb./(sec. ft.)
ρ	= Density, lb./cu. ft.
ρ_m	= Density of suspension, lb./cu. ft.
τ	= Shear stress, lb. force/sq. ft.
τ_y	= Yield stress, lb. force/sq. ft.
τ_w	= Shear stress at pipe wall, lb. force/sq. ft.

flow as already mentioned.) The branch point occurs at lower values of the shear stress as the pipe diameter increases. From a comparison of Fig. 5 and Curve (D), Fig. 1, it is evident that difficulty may be experienced in distinguishing dilatancy from turbulent flow of slightly plastic or pseudoplastic suspensions.

From tests on various suspensions, the apparent viscosity of a suspension in turbulent flow, determined from the usual friction factor vs. Reynolds number plot (see Fig. 6, p. 811, Perry[12]), is constant for all rates of shear or flow rates. The apparent viscosity of a suspension in turbulent flow has been called "turbulent viscosity".

Caldwell and Babbitt report that from their tests of clay and sewage suspensions acting as Bingham plastics, the usual friction factor vs. Reynolds number plot can be used, provided that the viscosity of the dispersion medium and the density of the slurry are used in the Reynolds number. They found the pressure drop to be independent of yield stress and coefficient of rigidity. Wilhelm, Wroughton, and Loeffel[21] obtained apparent viscosities greater than the viscosity of water for the cement rock-water suspensions they studied. Binder and Busher[2] presented data on grain-water suspensions behaving as Bingham plastics; the apparent viscosities were greater than the viscosity of the dispersion medium. The difference in all of these tests is probably due to concentration or particle size, or both. In some unpublished work on lime-water and titanium dioxide-water slurries of high concentration, which behave as pseudoplastics, the "turbulent viscosities" were approximately constant for all rates of shear and were from a few fold to several fold as great as the viscosity of the dispersion medium. Winding, Baumann, and Kranich[23] presented an interesting discussion of the viscosities of GR-S latices, which are pseudoplastics. In turbulent flow, a good correlation of pressure drop was obtained by using the "limiting viscosity at infinite shear" μ_∞ in the computation of the Reynolds number.

The following method may be used to determine the "turbulent viscosity." From values of $\Delta pD/4L$ and the corresponding values of $8q/\pi D^3$ for the turbulent flow part of the curve in Fig. 5, the friction factor can be computed from the Fanning equation:

$$f = \frac{\Delta p}{4L}\left(\frac{2\,g_c}{\rho_m V^2}\right) \qquad (6)$$

The Reynolds number corresponding to the friction factor determined from Equation (6) is obtained from the turbulent flow curve of the friction factor vs. Reynolds number plot. The "turbulent viscosity" μ_T is then computed from the Reynolds number:

$$N_{Re} = D\,V\,\rho_m/\mu_T \qquad (7)$$

In determining the pressure drop, or in sizing pipelines for turbulent flow, the "turbulent viscosity" determined from the pipeline viscometer data and the density of the suspension are used in the Reynolds number, and the friction factor is obtained from the usual friction factor vs. Reynolds number curve for turbulent flow. If tests cannot be made of the suspension in turbulent flow, an approximation for the "turbulent viscosity" can be made by using the coefficient of rigidity for Bingham plastics or the limiting viscosity at infinite shear for pseudoplastics. The pressure drop computed in this manner will probably be accurate within ±50 percent.

We have seen above that the yield value, apparent viscosity, thixotropic properties, and other desired rheological properties can be obtained from the shear diagram of the suspension. The rate of shear and shear stress are the only variables to be measured in order to obtain the shear diagram and are determined by a viscometer.

The use of capillary tubes or small pipes as viscometers has already been discussed. In addition, rotational viscometers are widely used. These are composed of two concentric cylinders, with one of the cylinders capable of being rotated. The suspension under test is between the two cylinders. The torque on the inner cylinder is measured for various rates of rotation of the rotating cylinder and from these measurements a shear diagram can be prepared. Rotational viscometers are suitable for evaluating flow properties of suspensions in which the solids do not settle rapidly, as the particles also tend to be thrown from the inner cylinder due to centrifugal force.*

Additional discussion of the theory and methods of analysis are beyond the intent of this article and reference should be made to the literature.[1, 6, 7, 14] Notes by the author covering the theory, measurement, and methods of analysis of the non-Newtonian flow of suspensions in pipes will be part of a book on special topics in fluid mechanics to be published by the University of Delaware.

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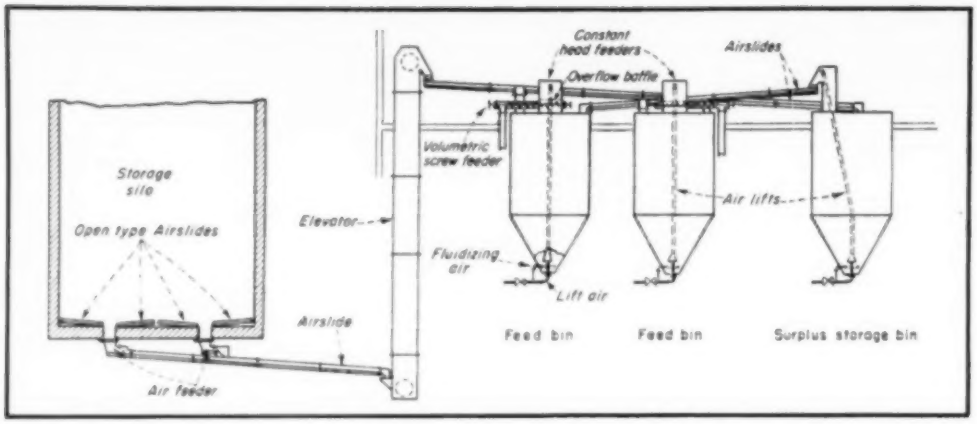
*There are several types of rotational viscometers. The MacMichael viscometer (Elmer and Amend) employs an outer cylinder or "cup" rotated by a variable speed drive electric motor. The torque on the stationary inner cylinder or "bob" is measured for various rotational speeds by a torsion wire attached to the bob. This viscometer is one of the best to study non-Newtonian suspensions. The "Precision" Interchemical rotational viscometer (Precision Scientific Co.) is similar in principle but its rotational speed range is considerably greater. A recorder has been developed[10] for this viscometer that automatically records the torque for various rotational speeds. The Brookfield "Synchro-Lectric" viscometer (Brookfield Engineering Laboratories) is one of the simplest rotational viscometers. It consists of a cylinder or "spindle" rotated by a variable speed drive electric motor; the outer cylinder is merely a large beaker. The torque on the spindle is measured for various speeds by a calibrated spring. The calibration is given directly in poises; however, this is the viscosity of a Newtonian fluid for the same speed and scale reading. This instrument, though not as flexible as the MacMichael viscometer, provides a rapid means of determining the presence and extent of the various rheological properties. The Stormer viscometer (Arthur H. Thomas Co.) has an inner cylinder that rotates within a stationary cup by the action of a falling weight. The rotational speed is determined by measuring the time required for a definite number of revolutions of the inner cylinder. The torque is determined from the weight and radius of the pulley. This instrument is not suitable for the study of thixotropy.

The Stormer viscometer can be conveniently used for determining the "turbulent viscosity" from a type of friction factor vs. Reynolds number curve for the instrument.[9] The curve for the instrument is obtained by using a Newtonian fluid such as water, glycerine, or oil. The type of curve obtained is shown in Fig. 6. The correlating factors W/ω^2 and a modified Reynolds number $n\rho/\mu$ are not dimensionless numbers. From one measurement of the torque and rotational speed for the suspension, such that W/ω^2 is in the turbulent region (see Fig. 6), the "turbulent viscosity" can be obtained from the value of the modified Reynolds number corresponding to the value of W/ω^2 obtained. The viscosity μ in this case is the "turbulent viscosity" μ_T.



Several methods of handling solids in a fluidized condition are shown here, including the new Airslide conveyor, solids air-lifts, and constant-head and air-actuated feeders. Little air is required compared with that used in pneumatic conveying.

Gas-Solids Fluidizing for Transport

Suitable mathematical treatment of fluidized transport systems is still unattained; meanwhile, design is based on experience

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In spite of a voluminous literature dealing with the many types of gas-solids systems encountered by the chemical engineer, it is frequently difficult for individuals who are not specialists in a particular type to evaluate the theoretical and engineering aspects of a particular problem. While the development of the theory and operation of some of these systems has been adequate to permit the application of generalized formulas, many others have unfortunately not been so developed in the available literature. Among the inadequately described systems are those which are usually referred to as "transport systems." These include two general types: those in which the conveyance of solids from one location to another is the principal objective, and those in which it is desired to alter the properties of one or both phases by reaction while they are in concurrent motion.

The principal reasons for the lack of reliable published data on transport systems are the multiplicity of variables encountered, and the lack of sufficiently exhaustive research to permit a complete correlation and mathematical treatment which will include all of the essential variables. In the face of such complex conditions, manufacturers of conveying equipment have been reluctant to publish information which has been acquired only by long experience. Furthermore, such data are to a large extent empirical in nature. Recently published studies[1] and others not yet published[2] illustrate the complexity of the problems involved in arriving at a mathematical treatment, and indicate that many heretofore uncertain relationships are gradually being solved.

SOLIDS LOADING

In the movement of gas-solids mixtures, the ratio between the two phases (solids loading of the gas) may vary over wide limits. This relationship is commonly expressed in terms of volume of gas associated with a unit weight of solid. Sometimes it is better considered as the ratio of weight of gas to weight of solids. The measure of loading may be used as a distinguishing characteristic in discussing a variety of systems where gas and solid particles are in concurrent movement.

The highest ratios of gas to solids are encountered in handling dusts and undesirable atmospheric contaminants, in reality a type of ventilation. Other examples of low solids loadings in moving gas streams are air-swept mills, and the various pulverizing systems in which a major portion of the size reduction is caused by particle to particle attrition while suspended in a flowing gas stream.

A somewhat denser mixture of a gas (usually air) and solids is found in the field generally referred to as "pneumatic conveying." Here movement of the solid particles is brought about by a high-velocity gas stream in which material remains suspended until discharged into a receiver. Such widely diversified materials as grains, flour, granular and pulverized chemicals, lime, soda ash, powdered or flake plastic, wood chips and coal may be conveyed in this way. Particle size may range from a few microns to several inches.

In planning a pneumatic conveying system, some of the variables which must be considered and integrated include: Desired capacity of the system; conveying distance, horizontal and vertical; particle size, shape and gravity; air pressure, density, volume and velocity; and pipe diameter, as well as types and number of bends. In removing materials from bulk storage by means of a pick-up nozzle, a reduced pressure or "vacuum" system is employed. When the material can be fed mechanically into the transport line, a positive pressure system is preferred. In either case, air in appropriate quantities must be available at the point of material

introduction. In vacuum systems, a maximum negative gage pressure equal to about 10 in. Hg is permissible, whereas in a pressure system about 6 psig. is the maximum pressure employed. Since the pressure, or vacuum, used at the point of feed has an economical top value, an increase in the length of line cannot be compensated for by increasing the amount of air, but only by a reduction in material capacity. It has been found that vacuum systems require about 50 percent more power to convey a pound of material than does a pressure system.

The volume of air used, between the approximate limits of 1 and 10 cu.ft. for each pound of material, depends not so much on the type of material, as on the length and configuration of the system. The gravity, fineness and shape of material particles all influence the amount of air, and thus the power required for conveying. It has been found, however, that the effect of any one of these variables cannot be expressed in a generalized statement applicable to more than the one material being considered. Such reasons as these explain why it is undesirable to rely on some of the simplified formulas in the literature for air volume and velocity, or power requirements.*

Physical characteristics of the material such as friability and abrasiveness frequently become major design considerations in pneumatic systems. In some cases they are determinative of the suitability of a high velocity pneumatic system for the material. In order to avoid caking or agglomeration, moisture content may also be critical. A tolerance of 1-4 percent moisture for flour, and even higher for certain grains, is common, whereas with clays, 6-7 percent is the normal maximum.

DENSE PHASE SYSTEMS

Solids Pumps—Pulverulent materials having suitable size ranges, if they can be fluidized, have for many years been conveyed up to distances of several thousand feet, including substantial elevations, by the Fuller-Kinyon "solids pump." In this device, a high speed screw advances the material from a feed hopper through a barrel, compressing it by means of reduced pitch flights to form a dense material seal. It then discharges the material into the conveying line in which there is usually a back pressure at the feed end of 10-15 psi., but which may be as high as 40 psi. Compressed air, added to the material as it is delivered from the screw into the conveying line, produces a fluent mixture and expands in the conveying line causing a gas-solids flow at a velocity considerably less than in pneumatic conveyors of the more usual type. Such pumps have been widely used for pulverized coal, cement, rock and mineral products, and chemicals. They have frequently been cited as one of the first commercial examples of the use of a fluidized solids system. The usual volume of air introduced at normal operating pressures is less than 0.5 cu. ft. per pound of material. With proper cooling of pump parts, such pumps are suitable for the transport of materials having temperatures up to about 800 deg. F.; with special materials of construction, even higher.

Blow Tanks—Another conveying system, suitable for conveying a variety of materials having widely different properties, is frequently referred to as the "blow tank." Such devices are a type of intermittently operating pump. They usually perform at pressures substantially higher than the "pneumatic systems" or the solids pumps, and are capable of conveying over longer distances. Air is introduced into the material in a closed vessel at pressures sometimes as high as 100 psig., and allowed to expand into the line. In this system there is no need, as in the case of the solids pump, for the material to have properties which render it "fluidizable." The gas-solids ratio in general lies intermediate of those in the solids pump and the pneumatic system. As an example of performance under high pressure, we may mention the conveyance of cement through a single pipe at a rate of 200 tons an hour over a distance of 7,600 ft. In a low pressure system, the fragile bead type catalyst of the Houdriflow process is being elevated over 200 ft. with a minimum of breakage.

Combination Systems—Where elevation of dry fluidizable materials with a minimum of horizontal transport is desired, a combination of dense and dilute phase fluidization may be employed. Such a system has advantages when applied to volumetric feeding* and in the blending of dry solids mixtures. The accompanying sketch includes an illustration of this system as used for elevating purposes, and for supplying a constant-head volumetric screw feeder. Near the bottom of each of the feed bins shown at the right of the sketch is the conical inlet end of the airlift pipe. Below this inlet, air is introduced through a porous medium to produce local fluidization, thus permitting the "hydrostatic head" of the remainder of the material to produce a continuous flow of fluidized material into the cone of the lift pipe. Additional air is introduced through a centrally located pipe having a slightly smaller diameter than the lift pipe.

This lift air enters the pipe at a low pressure, and with a velocity much less than an aspirator or jet would require. The volume used is dependent on the capacity desired, and on the properties of the solid. As a practical matter, the necessary fluidizing air shows little change from one material to another. The elevated material is delivered to a constant head box, the overflow from which returns to the bin. This provides a fixed head of constant-density material which is partially de-aerated over the feed screw, and assures a remarkably uniform delivery rate to a reaction vessel, rotary kiln or pulverized fuel feed pipe.

FLUIDIZED TROUGH CONVEYOR

Another type of gas-solids transport involving fluidization has recently been developed to a successful commercial scale by the Huron Portland Cement Co.*. These conveyors can handle large tonnages of pulverulent materials.* They are designed to operate under large heads of material in the open type to discharge bins and silos; or to convey materials through a duct in an inclosed type. The devices use a conveying surface, slightly inclined at 3-6 deg., which consists of a low-permeability porous medium. Over this a fluidized or partially fluidized mass of material flows under the influence of gravity. In addition to rock products and ores, a wide variety of chemical products can be handled.

As illustrated in the sketch, material in the storage silo at the left is delivered by open-type Airslides to one or more air-actuated feeders* which provide a material cut-off when the air supply is stopped by means of an adjustable gate and weir plate. An Airslide transports the material to an elevator which delivers it to another Airslide. The last conveyor keeps the material in the feed bins at desired levels and discharges any excess into a surplus storage bin. The surplus, when necessary, may be elevated by an airlift and returned to one or both of the feed bins by a third Airslide conveyor.

A smaller volume of air is used in this system than in any of the previously described methods of transport. With material under head, air at about 1 psig., and in the conveyor, air at 6-8 in. w.g., is supplied to one point in a continuous air chamber below the porous medium.

(*Continued on page 121*)

* Made under exclusive license from the Huron Portland Cement Co. by the Fuller Co. under name of F-H Airslide.

Flow in Fluidized Reaction Systems

Although data correlations which obviate experimental work are not yet developed, many fluidized systems are working successfully

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Fluidization of solids is commonly defined as that unit operation in which suitably sized solid particles are brought into vigorous agitation, similar to a boiling liquid, by the action of an upwardly flowing gas or liquid stream. Fluidized solids resemble liquids and gases in that they may be transferred from one vessel to another through pipes and ducts, and in that their flow may be controlled by valves of special design.

The principal advantages of fluidized solid systems, both catalytic and non-catalytic, are:

1. Excellent control and uniformity of temperature, thereby minimizing undesirable side reactions and the sintering of solids, at the same time improving quality and uniformity of products.
2. High overall coefficients of heat transfer, thereby increasing reaction vessel capacities.
3. High reaction rates owing to the large specific surface of the fluidized particles, which are kept relatively free of gas films by the turbulent state of the bed.
4. Cheap and easy movement of large quantities of solids from one vessel to another.
5. Possibility of maintaining a deep reaction bed of uniform temperature and conditions.
6. Catalysts need not be specially pelletted or otherwise prepared, although they must be of sufficient strength not to disintegrate under fluidizing conditions.
7. Provides a means of continuously removing a solid product of reaction from the reactor; an example of this is the process of catalytic cracking of petroleum gas oil in which coke is continually removed from the reactor and burned off in the catalyst regenerator.
8. Provides an excellent heat carrier for transferring heat to or removing heat from a reactor. This is especially important in highly endothermic or exothermic reactions.

There are, however, possible disadvantages or other considerations which may render fluidized systems inadvisable:

1. Because of the rapid top-to-bottom mixing which takes place in a fluid bed, occurring almost instantaneously when catalyst is introduced into the reactor, it is not possible to employ fluidized solids in countercurrent operations, except by using two or more reactors in series.
2. This mixing makes possible a certain amount of short circuiting of solid feed from the inlet to the outlet and in certain instances may mean that the vessel would have to be uneconomically large.
3. The rapid mixing which occurs also means that in withdrawing solids from the reactor, some fresh catalyst is withdrawn along with the spent catalyst, and in certain cases this may be undesirable.
4. Units must be carefully designed and operated to avoid erosion of lines and equipment.
5. Catalyst storage, handling, and recovery equipment, including cyclones and Cottrell precipitators, is relatively expensive.
6. If the catalyst is expensive, the inevitable loss by entrainment from the bed may make the operating costs prohibitive.

The greatest use of fluidization has been in catalytic cracking in the petroleum industry,[1] with a present fluid catalytic cracking capacity of approximately 1,000,000 bbl. per day in the United States. The techniques of fluidization have also been applied to the distillation of wood for recovering acetic acid[2] and for the manufacture of activated carbon[3] and other materials, the calcination of limestone or water-softening sludge and the roasting of ores,[4] the oxidation of naphthalene to phthalic anhydride,[5] and the synthesis of gasoline from hydrogen and carbon monoxide. The Carthage Hydrocol plant now under construction at Brownsville, Tex., is the first example of the last named application. Other possible uses of fluidization under study include the destructive distillation of coal and oil shale, the gasification of coal and coke, and the removal of mists and dusts from gases in a bed of fluidized solids.

THEORY NOW DEVELOPING

Considerable experimental work has been done in the last few years, and much more is now in progress. A good part of this will undoubtedly be published in the next several years, and so help to define the characteristics of fluidized systems and correlate the variables involved. As yet the scope of the experimental work has been relatively limited. The correlations derived from it must be used with caution when considering systems other than those from which the correlations were taken. Furthermore, as yet no completely satisfactory correlations have been published which obviate the need for experimental work under the fluidizing and reaction conditions contemplated for commercial use.

It has been shown[6] that when air, carbon dioxide, and helium are passed upward through a settled bed of round or sharp sands, the pressure drop within a Reynolds number range of 10^{-3} to 10, is expressed by:

$$\Delta p = \frac{200\, G\, \mu\, \phi_s^2\, L\, (1-\epsilon)^2}{D_p^2\, \rho\, g_c\, \epsilon^3} \qquad (1)$$

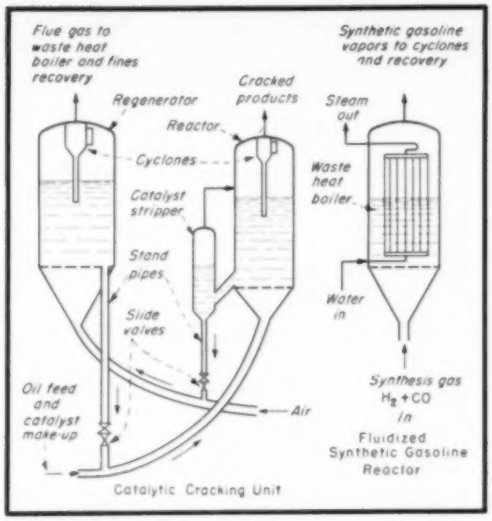
Here the modified Reynolds number is D_pG/μ and the flow is laminar. (See Leva, p. 115, this issue.) As the rate of flow is gradually increased the pressure drop rises to a maximum value expressed by Eq. (2) at which it equals the weight of solids in the bed divided by the cross-sectional area of the vessel:

$$\Delta p = (V_T/A_T)\,(1-\epsilon)\,(\rho_p - \rho) \qquad (2)$$

As the gas velocity is still further increased the pressure drop remains constant but the bed begins to expand. Since Eq. (2) gives the pressure drop of incipient expansion, the mass velocity necessary to start expansion may be determined by combining and rearranging Eqs. (1) and (2) to give:

$$G_e = \frac{0.005\, D_p^2\, \epsilon^3\, (\rho_p - \rho)\, \rho g_c}{\phi_s^2\, (1-\epsilon)\, \mu} \qquad (3)$$

Expansion of the bed alone is insufficient in many cases to permit fluidization and the expansion must continue until the bed reaches a condition which has been called[6] "maximum fluid density" or "minimum fluid voidage." At this point of incipient fluidization the fractional voids in



These sketches portray principles of two types of fluidized reaction systems, the catalytic cracker, and a proposed internal boiler design for synthetic gasoline production.

the bed equals the minimum fluid voidage, or $\epsilon = \epsilon_{mf}$ and the corresponding mass velocity G_{mf} may be calculated by determining Δp from Eq. (2) and substituting this value back into Eq. (1). As the rate of gas flow is still further increased beyond that necessary to start fluidization the pressure drop still remains that given by Eq. (2), but Eq. (1) no longer holds, since the flow is no longer laminar and added energy is required to maintain the internal motion of the particles in the fluid bed.[8]

HELPFUL RELATIONS

This introduces the concept of fluidization efficiency proposed by Leva et al.[9] This quantity equals the difference between the mass velocities necessary to fluidize the bed, and merely to expand it, divided by the mass velocity for fluidization:

$$E_f = (G_f - G_e)/G_f \tag{4}$$

from which the work of fluidization, or rate of energy dissipation, can be calculated as:

$$P = q\Delta p = G_f A_T \Delta p/\rho \tag{5}$$

Other useful relations of fluidized beds include that for bed expansion:

$$L_e = (1 - \epsilon_{mf})/(1 - \epsilon) \tag{6}$$

that for mass velocity for fluidization:

$$G_f = (G_{mf}/l_e)\,(G_{mf}/G_{de})^m \tag{7}$$

and an expression from which the fractional voids ϵ in a fluidized bed can be obtained:

$$\frac{(1-\epsilon)^{(2+1/m)}}{\epsilon^3} = \left(\frac{G_f}{G_{mf}}\right)^{1-m} \times \frac{(1-\epsilon_{mf})^{(2+1/m)}}{\epsilon_{mf}^3} \tag{8}$$

All fluidization is characterized by rapid and intimate top-to-bottom and side-to-side mixing of the solid particles. In addition, in glass laboratory units, convection currents may be seen, with an upward current in the center of the vessel and downward currents along the wall. These currents are not so pronounced in commercial units which usually have a smaller ratio of height to diameter.

The phenomenon of slugging is characterized by pressure drops through the bed which vary erratically, sometimes as much as 20 percent above or below the calculated value. It is caused by the coalescence of small gas bubbles rising through the bed to form a larger bubble across the entire cross-section of the vessel. Slugging is more likely to occur in small diameter equipment than in larger vessels because a single bubble across the entire cross-section is more easily formed. Because in deep beds the small gas bubbles have a longer time in which to coalesce, slugging also occurs more readily in tall beds than in shallow beds. In general it becomes more violent as the velocity is increased.

Channeling, the flow of gas through small channels in the bed, rather than more or less uniformly across the entire cross-section of the vessel, is also more likely to occur in small-diameter vessels where the smaller resistance to flow along the wall is more noticable than in larger vessels. Channeling in any given vessel is less apt to occur at high fluid rates, largely because the greater particle movement at higher rates destroys the channels. In general, it may also be said that fine particles channel more readily than do larger ones. Channeling is characterized by pressure drops smaller than predicted from Eq. (2).

Good size distribution, with the proper proportions of fine and large particles, promotes good fluidization. Poor size distribution helps to account for channeling and slugging. With too many fines, particles adhere to one another and channeling occurs; with insufficient fines slugging occurs. The optimum size distribution for a given solid material under a particular set of conditions can usually be determined only by experiment. The smooth fluidization range, or the range of gas velocities over which fluidization is obtained, is greater for small particles than for large particles. Whenever a material with a very wide range of particle sizes is used, classification of the material occurs. The smallest particles collect at the top of the bed and the largest particles at the bottom. Under such con-

NOMENCLATURE

- A = Surface area of individual particle, sq. ft.
- A_T = Cross-sectional area of reaction vessel, sq. ft.
- D_p = Average particle diameter, ft.
- e = Base of natural logarithms, 2.718 . . .
- E_f = Fluidization efficiency, dimensionless.
- g_0 = Conversion factor, 32.17 (lb. mass/lb. force) (ft./sec.^{2})
- G = Mass velocity, lb./(sq. ft.) (sec.).
- l_e = Expansion ratio of fluidized bed, dimensionless.
- L = Height of unexpanded bed, ft
- m = Slope of fluidization line in Ref. (9), i. e., plot of log $(1-\epsilon)^2/\epsilon^3$ vs. $G_{mf}l_e/\rho$; can be obtained from generalized curve, p. 623, Ref. (9).
- Δp = Pressure drop, lb./sq. ft.
- P = Energy dissipation rate, ft.-lb./sec.
- q = Volumetric flow rate, cu. ft./sec.
- t = Time, sec.
- t_c = Time of contact of gas with solids, sec.
- v_0 = Superficial fluid velocity, based on empty reactor, ft./sec.
- V = Volume of individual particle, cu. ft.
- V_f = Total volume of fluidized mass, cu. ft.
- V_T = Dumped volume of solids, cu. ft.
- W_s = Weight of bed solids, lb.
- x = Fraction of particles originally present, remaining at any time t, dimensionless.
- ϵ = Fractional voids in solids bed, dimensionless. Minimum fluid voidage ϵ_{mf} can be determined from generalized curves in Ref. (10).
- μ = Fluid viscosity, lb./(sec.) (ft.).
- ρ = Density (of fluidizing gas unless otherwise specified), lb./cu. ft.
- ϕ_s = Particle shape factor, dimensionless, = 0.205 $A_p/V_p^{2/3}$ (see Leva, p. 115, this issue).

SUBSCRIPTS

- e = Refers to expansion.
- f = Refers to fluidization.
- mf = Refers to minimum fluid voidage.
- p = Refers to particle.

ditions there is a gradation in the bed density, the greatest solid concentration occurring at the bottom and the least at the top.

Small particles pack into dense masses without aeration, often requiring pressure differentials for bed expansion much greater than those calculated by Eq. (2). Therefore, in large equipment, such as catalytic cracking units, aeration is maintained in all vessels, standpipes, and lines whenever catalyst is in the unit.

Other than particle size, the most important single variable in fluidizing operations is the linear velocity of the fluidizing gas. This is usually calculated on the basis of an empty reactor at the temperature and pressure of the reaction. In commercial operations, velocities of from 0.5 to 2.0 fps. are ordinarily used, the tendency being to operate at higher velocities. In effect, this means that if process considerations will permit a higher space velocity, a reactor of smaller diameter can be used.

The density of the fluidizing gas generally has an insignificant effect and the static pressure, even up to 500 psig., has a negligible influence on the pressure drop. This is because the particle density is usually so much greater than that of the gas. The viscosity of the gas is also relatively unimportant.[10] These properties do, however, affect the voidage in the bed slightly. The density of the solid particle has little effect on the fluidizing action with other conditions constant although of course it directly affects the pressure drop through the bed. However, it has been found that small particles may be fluidized more efficiently (i.e., with less energy to maintain their internal motion) than large particles.

HEAT TRANSFER IN FLUIDIZATION

Heat transfer to or from a fluidized bed is helped greatly by the scrubbing action of the turbulent solid on the gas film on the reactor wall, and also by the greater turbulence in the bed itself. Over-all coefficients of heat transfer 5-70 times those obtainable with gas films alone are obtained with fluidized beds. Tentative correlations giving the effects of solid concentration, particle size, and mass rate of flow upon coefficients of heat transfer have been presented by Mickley and Trilling,[4] but until much more study is given to the problem, final correlations can not be given. It was stated that, within the limits of the experimental data, the over-all coefficient of heat transfer increases as a power function of bed density for a given particle diameter, except for the smallest particles, and that for a given bed density, the coefficient increases with a decrease in particle size.

The effect of the mass velocity (or linear velocity) of the gas on heat transfer is uncertain. In certain cases the over-all coefficient of heat transfer appears to be unaffected by the gas velocity and in other cases it increases rapidly with increase in the gas velocity. It is probable that the effect of gas velocity on heat transfer rate depends on the effect which the gas velocity has on the fluidization itself. In those instances where an increase in the gas velocity improves the fluidization of the bed (i.e. by eliminating slugging or channeling), without greatly affecting the bed density, the over-all coefficient of heat transfer can logically be expected to increase.

Fluidized materials are transferred from one vessel to another through lines only by virtue of differences in pressures which ordinarily are attained by means of standpipes and slide-valves. For this purpose it is necessary that the solid have a reasonably rapid increase in fluidized density with a decrease in gas velocity, thus enabling the build-up of a relatively large static pressure in a short standpipe.

Kalbach[5] has investigated the probable residence time of a particle of fluidized solid in one or more reactors in series. For a single reactor he points out that the equation of Ham and Coe[4] applies:

$$x = e^{-(q/V_r)t} \qquad (9)$$

which shows that after time t the fraction of particles remaining, of those present at $t = 0$, depends upon the average holding time V_r/q, where q however is taken as the outflow rate to allow for the possibility that the weight of solids in the reactor may either increase or decrease due to reaction. Similar equations have been derived[6] for cases where reaction takes place, as well as for series reaction vessels.

Examples of such reactions are the carbonization and gasification of coal in fluid beds.

Also of interest in fluidized reactions is the time of contact of the gas with the solid which is:

$$t_c = L\rho/G = W_s/(\rho_f A_T u_s) \qquad (10)$$

Ordinarily the mixing of the product gases with the reactant gases is undesirable. Gilliland and Mason have shown[7] that there is little backward mixing of the gases. The mixing is somewhat greater for small ratios of reactor height to diameter, and the concentration of the product gas may be somewhat higher near the reactor wall because of the convection-type flow pattern. The effect of gaseous mixing depends on the reaction rate mechanism and relative rates of reaction and mixing. There is no effect for a zero order reaction, but the effect is detrimental for a higher order reaction on account of the dilution of the reactants with the products. With a low reaction rate the concentration gradient is small and the effect of mixing is not serious; it is more serious at high reaction rates but then the reactor length is not important as the necessary bed is usually shallow. It may, however, seem serious in cases where preferential adsorption of the products by the solids occurs.

When utilizing fluidization of solids in a catalytic process, consideration must be given to the effects of the process upon the physical properties of the catalyst. Particle size, shape, density, and strength (or resistance to attrition) may change. For example, formation of carbon on iron Fischer-Tropsch catalysts causes disintegration of the particles, smaller particle size, and a lighter particle density. The combined effect of these changes is to increase the expansion of the bed, with attendent problems in increased carry-over, fluidization difficulties, and lower rates of heat transfer.

Changes in the physical properties of the gases must also be considered. As already noted, changes in the density and viscosity of the fluidizing medium have little effect upon the behavior of the bed. However, if the reaction causes appreciable expansion or contraction of the volume of gas as it passes through the bed, a careful evaluation of the effect of this change in volume (and hence linear velocity) must be made.

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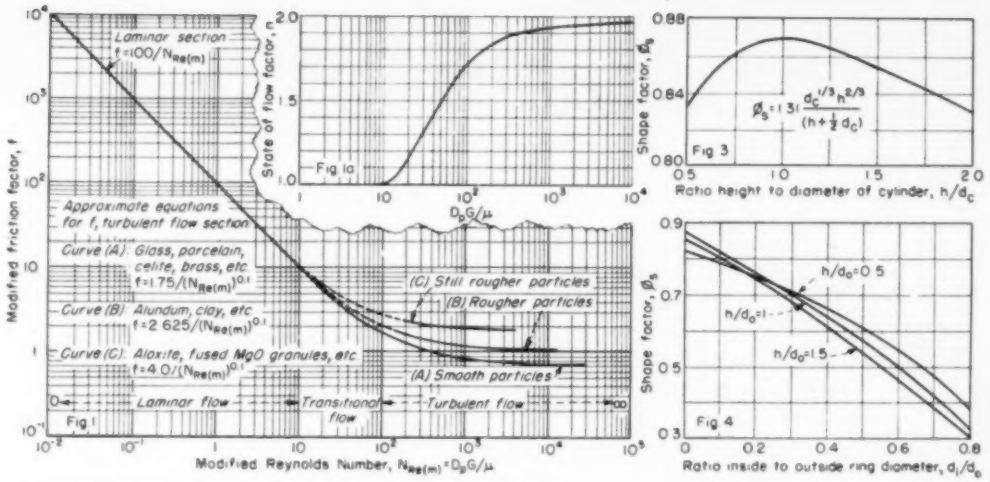

Fig. 1—Modified Reynolds number-friction factor plot for packed beds.
Fig. 1a—Plot of Reynolds number vs. state-of-flow factor n.

Fig. 3—Shape factor plot for cylinders.
Fig. 4—Shape factor plot for rings.

Fluid Flow Through Packed Beds

Pressure drop calculations are needed for many chemical engineering designs involving both fixed and moving beds

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An understanding of the laws of fluid flow through packed beds is of interest to a wide cross-section of engineers. In most cases, problems arising in this connection are of a practical nature and usually involve finding the optimum flow capacity of a system in relation to pumping, initial equipment, and maintenance costs. As an example, consider a packed reactor 6 ft. in diameter operating under a downward gas flow and a pressure drop of 1 psi. This requires that catalyst supports must be designed for the weight of the charge, in addition to a force of $36 \times 0.785 \times 144 = 4,075$ lb. Obviously, if catalyst bed and flow conditions were such as to require a pressure drop of 10 psi., the load due to the pressure drop would be 40,750 lb., increasing the cost of the supports as well as pumping and auxiliary equipment.

Packed systems employed in industry may be divided into the following classes:

1. Fixed beds
   (a) Solid-gas systems
   (b) Solid-liquid systems
2. Moving beds
   3. Solid-liquid-gas systems.

Typical examples of solid-gas fixed-bed systems are the catalytic reactors which were used by the Germans in the Fischer-Tropsch synthesis, retorting of oil shale, roasting of ores, combustion of coal and coke in fuel beds, and blast furnace operations.

Perhaps the most important solid-liquid fixed-bed applications are water filtration, flow of oil through sand strata, coal washing, and leaching.

Moving beds are employed in the TCC process and in pebble heaters.

The last class comprises fractionating towers, absorbers, scrubbers, and many other kinds of chemical engineering equipment. Simultaneous flow of natural gas and oil through sands and rocks is also of interest in oil and gas prospecting.

PACKED BED CHARACTERISTICS

In this paper, fluid flow will be discussed only in relation to equipment design and operation, eliminating considerations of flow through rock strata, naturally-occurring sand beds, and the like. In chemical reactors, it is desirable to achieve maximum space and catalyst utilization. This requires not only a high packing density but also reduction and possible exclusion of channeling phenomena. A channeling bed contains paths through which a disproportionate quantity of fluid passes, thus bypassing major portions of the catalyst. Obviously, such flow phenomena originate from non-homogeneous packing densities and the arrangement of the individual packing elements. In preparing a bed, care must, therefore, be exercised to obtain a uniform packing density and avoid bridging and the formation of dense centers, which, due to their greater resistance, will eventually induce channeling in certain portions of the bed. Berg et al.[1] reported that in some commercial hydroformers channeling reduced the efficiency of catalyst beds to approximately 55 percent.

Probably the most significant factor influencing resist-

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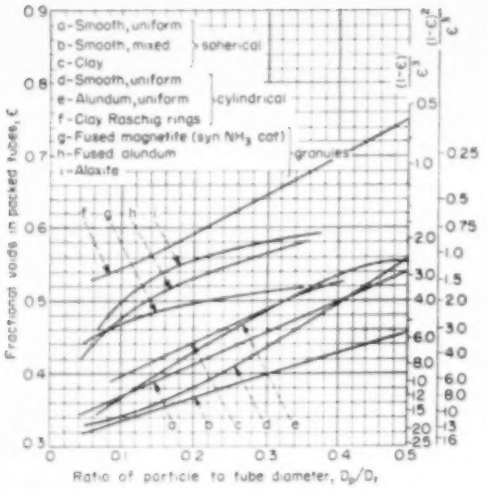

Fig. 2—Voids in tubes packed with various materials, for various ratios of particle diameter to tube diameter.

ance to flow is the fraction of voids in the bed. Thus, at otherwise constant conditions of mass velocity, particle diameter, and physical properties of fluids, a reduction in voidage from 50 to 40 percent may more than double the resistance through the bed. Since such variations in voidage are common between different packing materials, it seemed of sufficient interest to investigate the factors that influence packing density. Any generalized correlation along these lines should be of considerable value for estimating flow capacities of packed systems and catalyst holding capacities of vessels.

VOIDS IN TYPICAL PACKINGS

The results of such a study are shown in Fig. 2. Fractional voids have been plotted in relation to the ratio of particle to tube diameter. To render the correlation of most value for catalytic work, characteristics of the shapes most frequently used as packing, i.e., spherical, cylindrical, and granular, were investigated. Individual beds were prepared by slowly dumping the materials into vessels of 0.375 to 4 in. I.D.

In order to approximate "practical packing densities" which vibration will eventually bring about in commercial units, the sides of the tubes were tapped with a hammer for a time long enough to produce a maximum density under these conditions. From inspection of Fig. 2 it appears that particle shape and surface roughness are significant factors in determining the voidage. This effect can be shown readily by employing similar shapes of various degrees of surface roughness (ranging from glass to aloxite). The curves of Fig. 2 incorporate "wall effect"[9, 11] and are sufficiently accurate for the usual commercial engineering work.

For spherical and cylindrical particles, the particle diameter D_p is the diameter of the equivalent volume sphere. D_p values for granules are calculated according to $D_p = \sqrt{d_i \times d_o}$ where d_i and d_o are rated openings of adjacent sieve sizes. For mixtures of particles, satisfactory results are obtained when the average diameter is calculated according to $D_p = (Xd_p)_1 + (Xd_p)_2 + \ldots (Xd_p)_m$, where X is the weight percentage of any component, d_p the equivalent spherical diameter of any component and subscripts 1, 2 . . . m are the number of components in the mixture.

PACKED BED CORRELATIONS

1. Fixed Beds—For flow through fixed beds using either gases or liquids, the equation:

$$\Delta p = \frac{2 f G^2 L (1-\varepsilon)^{2-n}}{D_p g_c \rho_F \phi_s^{1-n} \varepsilon^3} \qquad (1)$$

has been supported by extensive data [2, 6, 8, 10, 11, 13, 19] ranging from runs performed with sands 400 mesh and smaller, to particles such as Berl saddles and complex ring packings.

A plot of the modified friction factor in relation to the modified Reynolds number D_pG/μ is shown in Fig. 1. For $N_{Re(m)} < 10$ the flow is laminar. The range $10 < N_{Re(m)} < 100$ is commonly referred to as transitional, whereas flows characterized by $N_{Re(m)} > 100$ are considered turbulent.

Investigations of the effect of surface roughness upon the pressure drop[18] have indicated a marked effect in the turbulent range, as indicated by the three curves. Approximate equations for f in this region appear on the curves. Roughness does not affect f in the laminar region as shown by the single curve and its equation.

These results are analogous to flow through empty conduits, where surface roughness was also found to be an important factor in the turbulent region.[18] A notable difference between packed bed and empty conduit flow is, however, found in the transition range. In empty vessels, the nature of the flow changes abruptly from laminar to turbulent at Reynolds number values of about 2,100, whereas the transition that occurs in packed tubes is a gradual one.

Substituting the proper expressions for f as given on Fig. 1 into general Equation (1), one obtains for laminar flow:

$$\Delta p = \frac{200\, G\, L\, \mu\, (1-\varepsilon)^2}{D_p^2\, g_c\, \rho_F\, \phi_s^2\, \varepsilon^3} \qquad (2)$$

and for turbulent flow and smooth particles (after a slight approximation):

$$\Delta p = \frac{3.50\, G^{1.9}\, \mu^{0.1}\, L\, (1-\varepsilon)}{D_p^{1.1}\, g_c\, \rho_F\, \phi_s^{1.1}\, \varepsilon^3} \qquad (3)$$

For the transitional range ($10 < N_{Re(m)} < 100$), the pressure drop is best estimated from Equation (1), taking f from Fig. 1 and the state of flow factor n from Fig. 1a.

INFLUENCE OF SHAPE FACTOR

In the above equations, consideration of the shape factor ϕ_s is of some interest. By definition, $\phi_s = 4.87\ V^{2/3}/A$. For spherical particles, $\phi_s = 1.0$, whereas, for all other shapes, $\phi_s < 1.0$. If the dimensions of an average particle are available, ϕ_s may be calculated for any particular bed. Figs. 3 and 4 give shape factors for conventional cylindrical and ring packings used in industrial work. Shape factors of most granules employed in catalysis range from 0.56 to 0.85. Thus, measurement (through pressure-drop observations) of ϕ_s for magnetite, referred to in Fig. 2, gave a value of ϕ_s of approximately 0.58; whereas, for the much rounder aloxite particles, ϕ_s is approximately 0.85.

For finely crushed sands and catalysts, shape factors vary between similar limits. Just as in the case of large granules, shape factors and outside surface areas of fine particles may be determined by observing pressure drops across specific beds. If the respective data for Δp, D_p, ε, etc., are substituted into Equation (1), it may be solved

NOMENCLATURE

A	= Surface area of particle of arbitrary shape, sq. ft.
D_a	= Average diameter of particles in a bed, by reciprocal mean method, ft.
D_p	= Diameter of an equivalent volume sphere, ft.
D_t	= Tube diameter, ft.
G	= Mass velocity based on vessel cross-section, lb./(sec.) (sq. ft.)
L	= Packed column height, ft.
N_{Re}	= Ordinary Reynolds number, D_pG/μ, dimensionless.
$N_{Re(m)}$	= Modified Reynolds number, D_pG/μ, dimensionless.
$N_{Re(m')}$	= Modified Reynolds number, $D_aG\ (1 - \epsilon)/\mu$, dimensionless.
V	= Volume of an individual particle, cu. ft.
X	= Weight fraction of a component in a mixture.
$d_1, d_2 \ldots d_n$	= Diameters of individual components in a mixture, ft.
f	= Modified friction factor of Eq. (1), dimensionless.
f_m	= Modified friction factor of Eq. (4), dimensionless.
g_c	= Conversion factor, 32.17 (lb. mass/lb. force) (ft./sec.^{2})
n	= State of flow factor from Fig. 1a, dimensionless.
Δp	= Pressure drop, lb./sq. ft.
ϵ	= Fractional voids in the bed, dimensionless.
ϕ_s	= Shape factor, $4.87\ V^{2/3}/A$, from Figs. 3 and 4, dimensionless.
ρ_F	= Fluid density, lb./cu. ft.
μ	= Fluid viscosity, lb./(sec. ft.)

for ϕ. While this method usually gives satisfactory results, it requires experimental facilities which are not always available. It is recommended, therefore, that for the usual process calculations, shape-factor estimations be made by visual comparison with bodies of known shape factor.[8, 10, 19]

Voidages in fine granular beds (over 400 mesh) usually vary between 40 and 60 percent[10] depending, primarily, on size-reduction and shape.

Equation (1) and its modifications[14] are also applicable to mixtures of sizes. The method of calculating particle diameter has already been stated.

2. *Moving Beds*—The first correlation of data obtained in moving beds has been suggested by Happel[12]. This investigator studied the flow of air through a wide variety of solids moving through experimental columns of 2 to 10 in. diameter.

Resorting to a modified friction-factor plot, Happle arrived at the following general correlation:

$$\Delta p = \frac{2\, f_m\, G^2\, L\, (1 - \epsilon)^3}{D_a\, g_c\, \rho_F} \qquad (4)$$

Plotting a modified friction factor curve for f_m vs. $N_{Re(m')} = D_aG\ (1 - \epsilon)/\mu$, Happel found that for $N_{Re(m')} < 3$, $f_m = 163/N_{Re(m')}$, and for $N_{Re(m')} > 300$, $f_m = 207/(N_{Re(m')})^{0.22}$. For the intermediate range between 3 and 300 Happel's friction factor plot must be used in combination with Equation (4). In this equation the particle diameter $D_a = 100/[(X/d_p)_1 + (X/d_p)_2 + \ldots (X/d_p)_n]$.

3. *Solid-Liquid-Gas Systems*—For systems of this kind, various empirical factors have been suggested[20] as well as equations[9] permitting estimation of pressure drop through rings and saddle packings. The equations mentioned are of the form:

$$\Delta p = U_s^n\, \rho^{0.2} / (a - b\sqrt{L})^n \qquad (5)$$

where Δp = pressure drop in inches of water head per foot of packed length; U_s = superficial gas velocity, ft. per min.; L = liquid rate, gpm. per sq. ft.; ρ = gas density, lb. per cu. ft.; n = a constant of approx. 2.0; and a and b are constants which are given in the tabulation below for a few tower packings.

Packing	a	b
1-in. Berl saddles	105	11
1½-in. Berl saddles	142	14
1½-in. Raschig rings	130	13
No. 6146 Drip Grids, straight flues	410	36.6

A more rational, though involved, approach for calculating pressure drop through packed liquid-gas systems has been presented by Brownell and Katz.[4] In their method, allowance is made for the effect of liquid rate upon the effective shape factor of the packing,[6] the voidage in the bed and, in addition, for the surface roughness of the material.

In general, it is found that, at a given mass velocity, resistance to gas flow through wet packed beds is higher than resistance through dry beds. No satisfactory explanation has been suggested; it seems that the chief reason for the higher pressure drops is due to the somewhat smaller voidage caused by liquid holdup.

In irrigated towers with gas flow, location of the so-called loading and flooding points are of particular interest. Below the loading point, liquid holdup is relatively independent of gas flow. If the column is operated at higher gas rates, the liquid holdup increases rapidly, and the flooding point is approached. For further details on these topics, the reader is referred to the literature.[9, 17, 21, 22]

CALCULATING AN EXAMPLE

Pressure drop is to be calculated for flow of air through a catalyst bed composed of smooth cylindrical pellets. These pellets are ⅝ in. in diameter and ½ in. high. The vessel has an inside diameter of 1.049 in. and the catalyst bed is 11½ in. in height. Air temperature is 75 deg. F. (μ = 0.000012 lb./sec. ft.), its pressure averages 16.45 psia. and its flow rate is 43.6 lb./hr. = 0.0121 lb./sec.

Solution—The catalyst pellets have a volume of $0.785(5/16)^2(\frac{1}{2}) = 0.0384$ cu. in. Then $D_p = (0.0384 \times 6/\pi)^{1/3} = 0.420$ in. and $D_p/D_t = 0.420/1.049 = 0.401$. From Curve ($d$), Fig. 2, $\epsilon = 0.50$. The height-to-diameter ratio of the pellets is $16/2 \times 5 = 1.6$ so, from Fig. 3, $\phi_s = 0.852$. The density ρ_F of the air is (29/359) (492/535) (16.45/14.7) = 0.0830 lb./cu. ft. and its mass velocity G is 0.0121 × 144/(0.785 × 1.049²) = 2.04 lb./(sec.) (sq. ft.). Then $N_{Re(m')} = D_pG/\mu = 0.420 \times 2.04/(12 \times 0.000012) = 5{,}900$. Since the flow is turbulent and the packing is smooth, substitution into Equation (3) gives a pressure drop of 1.99 lb./sq. ft. The actually observed value was 2.28 lb./sq. ft. and the voidage actually observed was $\epsilon = 0.56$.

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Pressure Drop Across Tube Banks

Flow characteristics of tube banks, both staggered and in-line, can be calculated by modifying pipe flow approach

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Pressure drop across tube banks has been studied quite extensively and a large amount of data are available. Several different methods of correlation have been proposed in the past. In general, pressure-drop data for tube banks can be presented in the form of a friction factor vs. Reynolds number plot (similar to the method used for analyzing pressure-drop data for pipelines) where velocity and dimensional terms are based on some arbitrary characteristic of the tube bank. (For example, see Lapple, p. 100, this issue.) However, in the case of tube banks, tube spacing and configuration (Fig. 1) introduce an additional variable which cannot be allowed for in the usual concept of friction factor and which results in a lack of geometric similarity between banks of different tube spacing and arrangement. The difference between the various proposed methods of correlation lies essentially in the definition of the characteristic dimensions of the tube bank and in the method of allowing for or incorporating the tube spacing and arrangement. The material presented hereinafter represents the best methods available for the estimation of pressure drop across tube banks for both turbulent and viscous flow and both staggered and in-line arrangements.

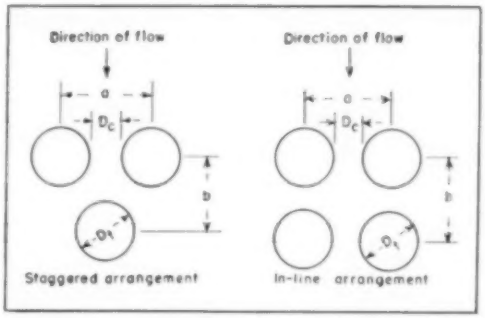

Fig. 1—Tube layout and dimensions, staggered and in-line.

TURBULENT FLOW

For the turbulent flow region, the pressure drop may be calculated from the following equation, using consistent units:

$$\Delta p = 4 f N \left(\frac{\rho V_{max}^2}{2 g_c} \right) = 4 f N \left(\frac{G_{max}^2}{2 g_c \rho} \right) \quad (1)$$

Staggered Arrangement—For banks of staggered tubes, the most direct solution for the friction factor is the one proposed by Chilton and Genereaux[4] and given by Equation (2). This equation is recommended particularly for the common commercial spacings, i.e., transverse pitches in the range of 1.25 to 1.50 tube diameters.

$$f = 0.75 / (D_t V_{max} \rho / \mu)^{0.2} \quad (2)$$

The accuracy in this range is probably ± 25 percent. The flow may be considered to be turbulent for values of the Reynolds number $D_t V_{max} \rho/\mu > 40$. The use of D_t (transverse tube clearance) in the Reynolds number was a judicious choice in that it made at least partial allowances for the effect of transverse spacing and, in addition, the longitudinal spacing has since been shown to have but a minor effect on the friction factor in the case of staggered arrangements. It has been assumed in the foregoing discussion that the minimum area for flow occurs in the transverse openings. However, if this minimum area occurs in the diagonal openings, Equations (1) and (2) can still be used by defining D_t as the diagonal clearance, N as the number of rows of tubes in the direction of flow less one, and V_{max} as the velocity through the diagonal openings.

For banks of staggered tubes having transverse pitches greater than 1.50 tube diameters, or in general where greater accuracy is needed than is given by Equation (2), it is recommended that the friction factor term for use in Equation (1) be selected from the Grimison charts,* shown in Figs. 2 and 3. Each "fence" represents a specific Reynolds number $D_t V_{max} \rho/\mu$ where D_t is the tube diameter. For intermediate Reynolds numbers, it may be necessary to interpolate by drawing a curve through values obtained from two or more of the "fences," although in most cases visual interpolation is adequate.*

With the Grimison charts, again, if the minimum area occurs in the diagonal openings, N should be taken as the number of rows less one, V_{max} should be based on the diagonal clearance area, and f taken from Fig. 3. Thus, V_{max} is always based on the minimum area available for flow. The Grimison correlation[3] was based solely on the data of Pierson[10] and Huge.[7] However, Boucher and Lapple,[2] in a recent evaluation of this correlation, found that the average deviation of the correlation from all of the available data was only ± 15 percent.

In-Line Arrangement—For banks of in-line tubes (rectangular arrangement), the pressure drop can be calculated using Equation (1) and taking the friction factor from the Grimison chart[3] in Fig. 4. Here again, each "fence" represents a specific Reynolds number $D_t V_{max} \rho/\mu$, where D_t is the tube diameter. For intermediate Reynolds numbers it may be necessary to interpolate either graphically or visually. The probable precision, as indicated by the Boucher and Lapple comparison[2] is likewise ± 15 percent.

Effect of Number of Rows—The charts and equations given up to this point are based on banks of ten or more rows in depth. For the case of turbulent flow through banks less than ten rows deep, the average friction factor per row will be somewhat higher. The magnitude of this increase is dependent upon the tube spacing and arrange-

* Note: To interpolate at a Reynolds number between any two of the "fences," the lateral distance between any two corresponding points on the two "fences" is proportional to the difference in Reynolds number of the "fences." A logarithmic scale marked off on paper from the f scale can be used to determine the interpolated point laterally, while vertically it will lie on the "faired" line through the corresponding points on all four "fences."—Editor

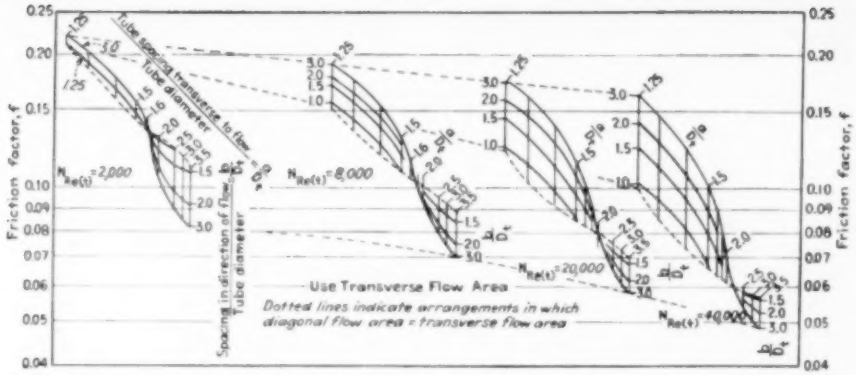
Friction factor, f
Tube spacing transverse to flow / Tube diameter
Spacing in direction of flow / Tube diameter
N Re(t) = 2,000
N Re(t) = 8,000
N Re(t) = 20,000
N Re(t) = 40,000
Use Transverse Flow Area
Dotted lines indicate arrangements in which diagonal flow area = transverse flow area

Fig. 2—Friction factors for staggered tube banks with minimum flow area in transverse openings.[6]

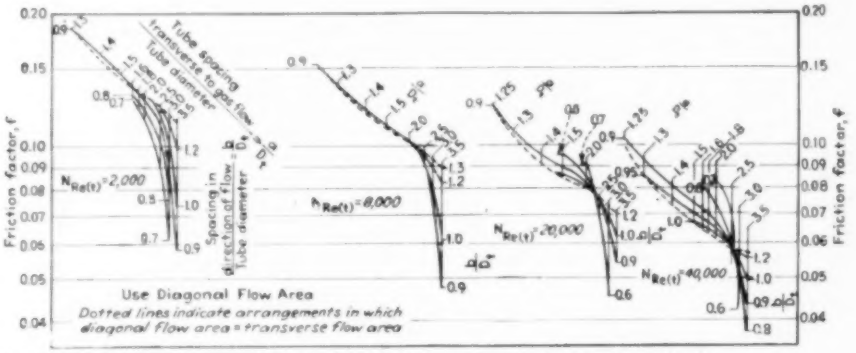
Friction factor, f
Tube spacing transverse to gas flow / Tube diameter
Spacing in direction of flow / Tube diameter
N Re(t) = 2,000
N Re(t) = 8,000
N Re(t) = 20,000
N Re(t) = 40,000
Use Diagonal Flow Area
Dotted lines indicate arrangements in which diagonal flow area = transverse flow area

Fig. 3—Friction factors for staggered tube banks with minimum flow area in diagonal openings.[6]

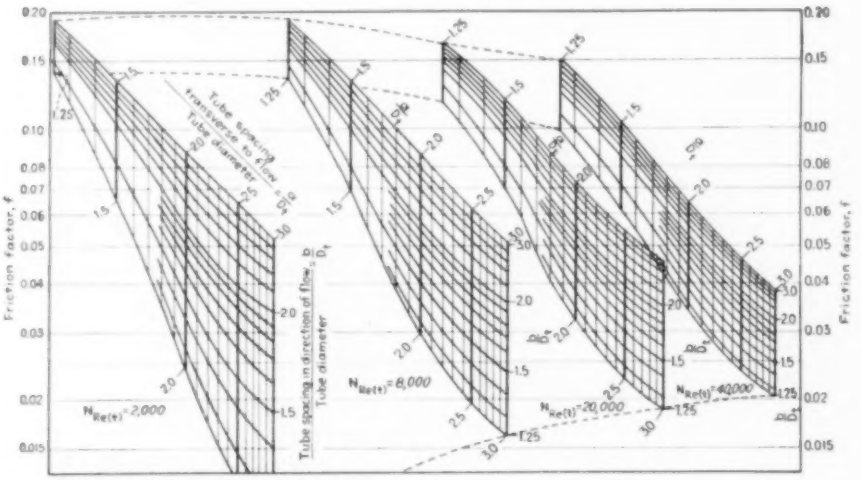
Friction factor, f
Tube spacing transverse to flow / Tube diameter
Tube spacing in direction of flow / Tube diameter
N Re(t) = 2,000
N Re(t) = 8,000
N Re(t) = 20,000
N Re(t) = 40,000

Fig. 4—Friction factors for in-line tube banks.[6]

ment. However, the maximum increase likely to be encountered is about 30 percent per row for two rows, 15 percent per row for three rows, and 7 percent per row for four rows. For flow normal to a single row of tubes, reference should be made to a plot of friction factor vs. transverse spacing given by Boucher and Lapple.[3]

Effect of Heat Transfer—For the case of a gas flowing across a tube bank and being heated or cooled, it is necessary to select a suitable mean temperature upon which to base the gas properties. The mean temperature for gases may be taken as:

$$t_m = t_1 + K_t \, \Delta t_m \tag{3}$$

Values of K_t, averaged from the recommendations of Chilton and Genereaux[4] and Grimison[5] may be taken as 0.75 for staggered, or 0.9 for in-line arrangements with gases being cooled; and as −0.8 for staggered, or −0.9 for in-line arrangements with gases being heated.

In the case of non-isothermal flow of a *liquid* across a tube bank, the friction factor is sensibly increased if the liquid is being cooled, and decreased if the liquid is being heated. As an approximation, it is recommended that the non-isothermal correction factor presented by Sieder and Tate[12] for turbulent flow in pipes be applied. This is adequately expressed by Equation (4), which gives the non-isothermal friction factor in terms of the isothermal friction factor:

$$f_n = f \, (\mu_w / \mu_a)^{0.14} \tag{4}$$

The isothermal friction factor is thus first evaluated using the average main-stream temperature, after which Equation (4) is used to give f_n. Equation (1) is then employed using f_n in place of f.

VISCOUS FLOW

Staggered Arrangement—The correlation presented by Chilton and Genereaux[4] and given by Equation (5) is recommended for the calculation of pressure drop for viscous flow across a bank of tubes on the equilateral-staggered arrangement (see Fig. 1) in which case $b = 0.816a$.

$$\Delta p = \frac{53 \, \mu \, L \, V_{max}}{g_c \, D_e^2} \tag{5}$$

The equivalent diameter D_e is given by Equation (6) for either staggered or in-line arrangements:

$$D_e = \frac{4 \, ab - \pi \, D_t^2}{\pi \, D_t} \tag{6}$$

The length term should be taken as the product Nb. The flow may be considered to be viscous for all values of $D_e \, V_{max} \, \rho / \mu$ less than 150.

The viscous flow correlation given above was based on data of Sieder and Scott[11] for two equilateral-staggered arrangements with transverse pitches of 1.25 and 1.59 tube diameters, and should therefore be used with caution for spacings outside of this range. Omohundro, Bergelin, and Colburn[9] recently presented some new data on isothermal viscous flow across a bank of tubes on equilateral-staggered arrangement with a transverse pitch of 1.25 tube diameters. Their data fell on a line 12 percent above that given by Equation (5) and 17 percent below that given by the correlation of Gunter and Shaw.[6]

Still more recently Bergelin, Davis and Hull[2] have presented data on isothermal viscous flow across tubes on a staggered square arrangement (see Fig. 1) for which case $b = 0.5a$. Their data plotted as friction factor vs. Reynolds number fell on a line roughly 100 percent above the Chilton and Genereaux[4] line. Therefore, for this arrangement, it is recommended that the pressure drop given by Equation (5) be multiplied by a factor of 2.

In-line Arrangement—These same workers[2] also presented data on isothermal viscous flow across a bank of tubes on an in-line square arrangement, in which case $a = b$ (Fig. 1). Their data indicated that for this case the pressure drop given by Equation (5) should be multiplied by a factor of 1.5.

Effect of Heat Exchange—For the case of non-isothermal viscous flow of a liquid across a tube bank, the friction factor is sensibly increased if the liquid is being cooled, and decreased if the liquid is being heated. As an approximation, it is recommended that the non-isothermal correction factor presented by Sieder and Tate[12] for viscous flow in pipes be applied. This is equivalent to calculating the isothermal pressure drop using Equation (5) and basing the viscosity term on the average mainstream temperature, and then multiplying by the factor $(\mu_a / \mu_w)^{0.26}$ to get the non-isothermal pressure drop.

EXTENDED SURFACES

Flow across banks of externally-finned tubes has not as yet been studied very extensively. Jameson[8] carried out tests on the flow of air across banks of helically-finned tubes on staggered arrangement. A wide range of tube spacings (both transverse and longitudinal) was employed to determine the effect of tube spacing on pressure drop. Gunter and Shaw[6] proposed a general correlation for both viscous and turbulent flow which appears to represent the data on certain types of extended surface.

HEAT EXCHANGERS

Tube Bundles—The problem of pressure drop across banks or bundles of tubes is encountered most frequently in estimating the pressure drop on the shell side of a shell-and-tube baffled heat exchanger. Here, the presence of the segmental baffles at right angles to the tube bundle

NOMENCLATURE

a	= Transverse pitch (see Fig. 1), ft.
b	= Longitudinal pitch (see Fig. 1), ft.
B_c	= Tube clearance (see Fig. 1), ft.
D_e	= Equivalent or hydraulic diameter (see Eq. 6), ft.
D_s	= Shell diameter, ft.
D_t	= Tube diameter, ft.
f	= Isothermal friction factor, dimensionless.
f_n	= Non-isothermal friction factor, dimensionless.
g_c	= Conversion factor, 32.17 (lb.mass/lb. force) (ft./sec.^{2})
G_{max}	= Mass velocity through the minimum area available for flow in tube bank, lb./(sq.ft.) (sec.) = $V_{max} \rho$.
K_1	= Constant, dimensionless.
K_2	= Clearance factor, ft.
L	= Length of tube bundle in direction of fluid travel = Nb, ft.
L_B	= Distance between baffles, ft.
N	= Number of tube rows in direction of fluid travel (except for case of staggered arrangements where maximum velocity occurs in the diagonal openings, whereupon it is number of rows less one), dimensionless.
N_t	= Total number of tubes in heat exchanger tube bundle, dimensionless.
$N_{Re(t)}$	= Modified Reynolds number $D_t \, V_{max} \, \rho / \mu$, dimensionless.
t_m	= Mean gas temperature from Eq. (3), deg. F. or C.
t_t	= Average tube-wall temperature, deg. F. or C.
V_B	= Velocity through net free baffle opening, ft./sec.
V_{max}	= Velocity through minimum area available for flow in tube bank, ft./sec.
W	= Weight rate of flow, lb./sec.
Δp	= Pressure drop, lb. force/sq.ft.
Δt_m	= Logarithmic mean temperature difference between tubes and fluid, deg. F. or C.
μ	= Fluid viscosity, lb./sec. ft.
μ_a	= Fluid viscosity based on average fluid main-stream temperature, lb./sec. ft.
μ_w	= Fluid viscosity based on average tube-wall temperature, lb./sec. ft.
ρ	= Fluid density, lb./cu.ft.

causes the shell fluid to flow across the tube bundle a number of times in traversing the length of the exchanger. Thus, the over-all pressure drop is made up of the shell inlet and exit nozzle losses, the summation of the losses for the passes across the tube bundle, and the summation of the losses across the baffle openings.

The situation with respect to any exact computation of the tube bundle losses is far from ideal for the following reasons. In any commercial heat exchanger there are finite clearances between the tubes and the baffles, and between the baffles and the shell, and the leakage through these clearances causes an appreciable reduction in the flow across the tube bundle. Although this reduces the pressure drop through the unit, the advantage is more than offset by the resulting reduction in heat transfer. The flow conditions are also abnormal in the sense that the fluid enters the bundle directly following a turn and does not necessarily flow normal to the tubes. It even flows parallel to some of the tubes in the case where some of the tubes pass through the baffle openings. Also, because the shell is cylindrical, the number of tubes per row varies across the tube bundle.

In spite of the above discrepancies, it is reasonable to estimate the pressure loss per pass using the standard equations for tube banks. An average value of V_{max} should be used based on the average number of tubes per row across the bundle. The number of rows or length of travel per pass should be taken as twice the distance from the shell axis to the center of a baffle opening. Because of leakage the answer so obtained will be highly conservative, and no additional factor of safety is required.

Baffle Openings—The pressure drop across a segmental baffle opening may be estimated roughly for turbulent flow from Equation (7):

$$\Delta p = 2\ \rho\ V_w^2/2g_c \qquad (7)$$

Actually, the loss across a given baffle opening will be affected markedly by the baffle spacing and whether or not the tubes pass through the opening. Again, because of leakage, Equation (7) will be conservative and further refinements are hardly justified.

Effect of Clearances—The effect of tube-to-baffle and baffle-to-shell clearances and the resulting leakage can be estimated where such clearances can be predicted. However, clearances differ widely from one make of exchanger to another, and even between different units of the same make because of shop tolerances. Also the clearances change with use because of accumulations of dirt.

The effect of clearances has been studied by several investigators, and those readers interested in further details are referred to papers by Tinker,[14] Short,[13] and Bowman.[8] Bowman derived the following equation, which can be used for a rough estimate of the effective mass velocity across tube bundles, allowing for leakage. The equation applies only to cylindrical tube bundles:

$$G_{max} = W/[L_B/D_e - D_t\sqrt{1.27\ N_t} + 1.25\ K_e D_t N_t] \qquad (8)$$

The clearance factor K_e was determined experimentally by Bowman to have a value of 0.01 ft. for one group of exchangers.

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Gas-Solids Fluidizing for Transport

(Continued from page 111)

The permeability and properties of the medium used assure an equal distribution of air throughout the length of the conveyor.

REACTION TRANSPORT SYSTEMS

Gas-solids systems for carrying out chemical reactions or modifying the properties of one or both phases include two general types, the "fluidized bed" and the "transport system." In several instances a combination of the two occurs in which the fluent nature of the gas-solids mixture permits movement from one vessel to another. The outstanding example is the fluid catalytic cracking process. Here finely divided catalyst in a dense fluidized condition passes from a standpipe into a transport line due to the "hydrostatic head." In the line it is changed to a more dilute gas-solid mixture and conveyed by the introduction of one of several gaseous materials. What may be accomplished by manipulation of gas-solids ratios and velocities will be appreciated from a study of the published descriptions of this process.[2, 7, 9, 10, 11]

Indirect heating and cooling of fine solids in a fluidized state while in transit have been practiced for many years, although over-all heat transfer is not high on account of short holding time and limited heat transfer surface. An early example is found in the preheating of cement raw material mixtures prior to introduction into a rotary kiln. A dense fluidized kiln feed is passed by a solids pump through a coil placed in a heat exchange tower.[1] Hot kiln gases flow through the tower before discharge to the stack. Cooling also has frequently been accomplished by pumping hot solids mixtures through pipes immersed in water.

An early example of carrying out a chemical reaction between a gas and solid in a fluidized mixture is found in the use of a Fuller-Kinyon transport line[6] to reduce the free lime content of portland cement by including moisture and carbon dioxide in the fluidizing air. Other applications of this principle include the dehydration of gypsum and the reduction of oxide ores. Fluidizable materials containing undesirable proportions of moisture may be dried rapidly in heated transport lines leading to receivers for separating solid and gas phases prior to condensation. Another type of drying is illustrated by the use of heated air in air swept grinding mills. All such operations must be rapid due to the high velocities and short holding times in the reaction zones.

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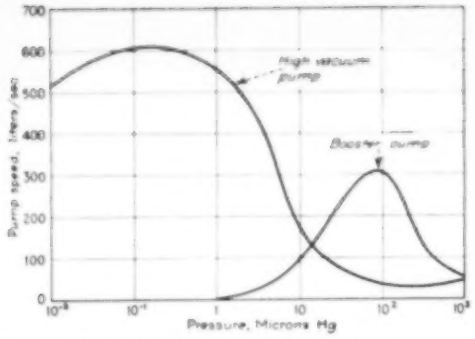

Fig. 1—Typical speed curve for a diffusion pump.

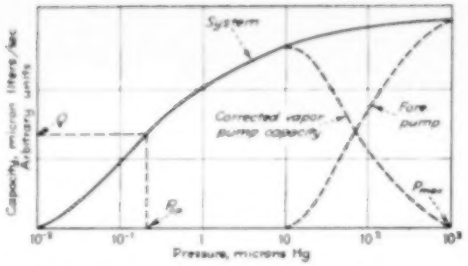

Fig. 2—Capacity curve for a high vacuum system.

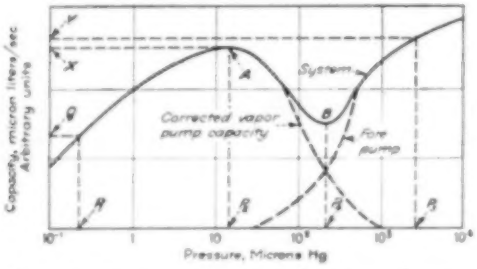

Fig. 3—Capacity curve for mis-matched vapor and forepump.

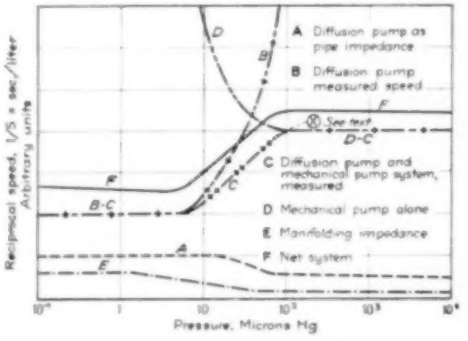

Fig. 4—Plot of reciprocal speed for elements of a system.

Flow of Low Pressure Gases

Flow in the range of high vacuum encounters problems that are unknown at the pressures familiar to most engineers

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In the last decade processes employing pressures of 1 mm. Hg and lower have expanded from a small laboratory scale to very large scale industrial type equipment. Meanwhile, the design, construction and operation of industrial vacuum systems have been growing out of the cookbook stage and are approaching the state of a mathematically sound engineering science. The reliability of the flow concepts and equations has now been proved for conductor diameters in excess of 30 in. and lengths approaching hundreds of feet. Nevertheless, many vagaries still exist that must be resolved and tested before vacuum process design can become a handbook manipulation.

There are a number of works treating gas flow at reduced pressure, to which the reader is referred for a more rigorous treatment than can be presented here.[1,2,3,4,5] This paper will confine itself to the simpler concepts and will present engineering tools that are useful in system design.

Since the units employed in high vacuum work are likely to be strange to engineers accustomed to flow at higher pressures, it is desirable first to define the more important ones. The relation between driving force, pipeline resistance and flow may be likened to the comparable quantities in a direct-current electric circuit where current = voltage drop/resistance, or $I = \Delta E/R$. If C, the conductance, is $1/R$, then $I = \Delta E \cdot C$. Similarly, in fluid flow, $Q = \Delta P \cdot C$. In high vacuum work the quantity of gas flowing Q is usually expressed in pV units per second, such as micron liters, micron cu.ft. or millimeter cu.ft. per sec.*

The driving force ΔP is pressure drop in microns and C is the conductance in liters per sec. at the inlet pressure. The conductance C is often referred to interchangeably as the "speed" S of the pump, manifold or total system. This unit also is expressed in liters per sec. The reciprocal conductance $1/C$ is often referred to as impedance.

Looking at this relation from a somewhat different viewpoint, from Eq. (1) it is evident that the operating pressure in microns maintained in a vacuum process is a function of quantity of gas handled and system speed or:

$$P_{op} = Q/S. \qquad (1)$$

This equation is generally the starting point in system design inasmuch as the required operating pressure and the rate of gas evolution in the process will be known, and the engineer can then determine the necessary system speed to maintain this operating pressure. Strictly speaking, this pressure is actually a pressure drop in the system, needed to conduct the gas evolved from the process to the pump.

* Although this unit has the dimensions of energy, it can be considered as a definite mass of a particular gas, i. e. as a number of liters of the gas at the existing pressure. To make the concept clearer, 1 cc. of gas at NTP = 760 micron liters or 0.760 mm. liters.

Eq. (2) recognizes this fact and supplies the correction:

$$1/S_s = 1/S_p + 1/S_m \qquad (2)$$

Here the quantity S_p is the speed of the pump, which varies with the pressure as Fig. 1 indicates, while S_m, the speed of the manifolding (piping, valves and fittings) is a quantity depending on the dimensions of the equipment and sometimes on the pressure, as will be shown.

FLOW IN VACUUM SYSTEMS

At the higher absolute pressures in the vacuum range, the laws of viscous flow apply and the quantity of gas handled per unit pressure drop is a function of the fourth power of the conductor diameter. When the pressure is reduced so low that the molecular mean free paths are of the same order as the dimensions of the conductor, then the flow per unit pressure drop is proportional to the third power of the conductor diameter. At pressures between those where viscous flow maintains and those where free molecular flow occurs, both types of flow co-exist and both contribute to the movement of the gas. Normand[7] has given a good rule of thumb for determining which type of flow is predominant. If the product of the average pressure in microns and the pipe diameter in inches is equal to or less than 7, then with small error the flow can be considered as free molecular. On the other hand, if the average pressure in microns times the pipe diameter in inches is equal to or greater than 220, the flow is predominantly viscous. For the intermediate range, the general flow equation has been simplified[7] to:

$$S_m = 0.25\,(D^3/L)\,P_{av} + 5.4\,(D^3/L) \qquad (3)$$

In this equation the term containing D^3 is the predominant one in viscous flow and can be used alone at values of P_{av} D greater than 220. The term containing D^3 (which it will be noted is independent of the pressure) is the predominant one in free molecular flow and can be used alone at values at P_{av} D less than 7. The equation applies only to air at 20 deg. C. flowing in long cylindrical pipes where the length in feet is at least equal to the diameter in inches. For other gases or temperatures, corrections must be made by multiplying by the square root of the molecular weight and temperature ratios, bearing in mind that higher temperature or lower molecular weight causes increased gas flow and hence speed.

Short pipes, cross-sections other than circular, and abrupt changes in cross-sectional areas all lead to correction factors in the speed of a conducting element. It is not within the scope of this paper to cover these ramifications which have been dealt with by Dyer[2] and Normand.[7]

For the usual case of cylindrical pipes and air at 20 deg. C., values of pipe speed sufficiently accurate for design may be had from Fig. 5, as given by Brown, Dinardo, et al.[3] Values taken from this chart for the free molecular flow range (i.e., the curving section of the positive slope lines) are slightly high as compared to Normand's results.

The graph gives conductance or speed in cu.ft. per min., or its equivalent, micron cu.ft./(min.) (micron pressure drop). To convert to liters per sec. the conversion factor is: liters/sec. = cu.ft./(min.) × 2.12).

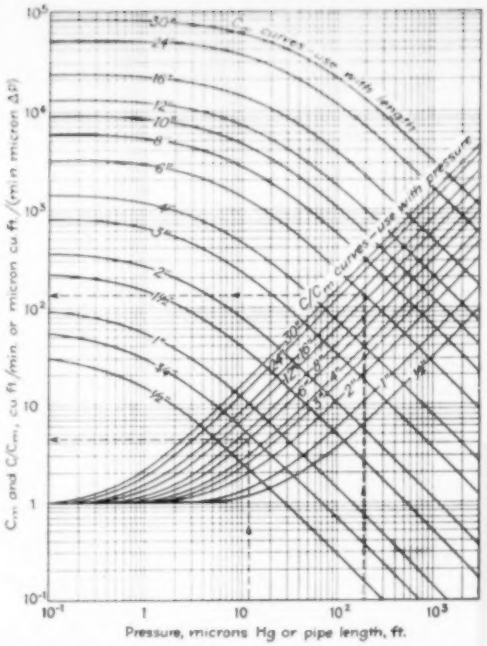
C curves - use with pressure
C/Cm curves - use with length
Cm and C/Cm, cu ft./min. or micron cu ft./(min micron ΔP)
Pressure, microns Hg or pipe length, ft.

Fig. 5—Chart for determining pipe conductance as contributed by both molecular and viscous flow.[3]

Use of the chart consists in three steps. The molecular conductance C_m for the proper pipe diameter and length (which is independent of the pressure) is first determined from the intersection of the proper negatively sloped pipe diameter line with the pipe length in inches. At pressures close to 1 micron it will be noted that this quantity accounts for the principal part of the total conductance. The molecular conductance is then corrected for viscous flow by determining a factor C/C_m from the intersection of the proper positively sloped pipe-diameter line with the average system pressure. It will be noted that this correction is negligible at low pressures, but becomes large at pressures where viscous flow predominates. The two quantities are then multiplied together to give C. For example, for 190 in. of 6-in. pipe at 12 microns, $C = C/C_m \times C_m = 4.4 \times 130 = 572$ cu.ft./min. the conductance due to both free molecular and viscous flow.

Under dynamic conditions of operation, each element in the system must handle the quantity of gas which comes to it from the preceding element, plus any additional gas in-leakage within the element. This is equivalent to the equation of continuity:

$$S_p\,P_{p(av)} \geq S_m\,P_{m(av)} \geq S_s\,P_{sp} \geq Q \qquad (4)$$

which states that the speed of the pump times its mean pressure is equal to or greater than the speed of the manifold times its mean pressure, which in turn is equal to or greater than the speed of the low pressure chamber, times its mean pressure, which is equal to or greater than the quantity of gas evolved in the process.

Equation (2) can be solved for the speed of the manifold S_m required to give a desired speed of the system S_s only after a value can be substituted for the speed of the pump. Solution of the over-all design therefore requires proper selection of the pump. For large-scale production of sub-millimeter pressures, the engineer today is fairly well committed to oil vapor diffusion or booster pumps.

Such pumps compress a gas from low pressure at the pump inlet to a high enough pressure so that a backing pump, or forepump, may then push the gas out against

NOMENCLATURE

C	= Conductance = speed, liters/sec.		
D	= Inside diameter, in.		
L	= Length, ft.		
P	= Pressure, microns Hg.		
ΔP	= Pressure drop, microns Hg.		
Q	= Capacity, micron liters/sec.		
S	= Speed = volume rate of flow, liters/sec.		
t	= Time, sec.		
V	= Volume, liters.		

SUBSCRIPTS

1	= Initial.	m	= Manifold or molecular.
2	= Final.	op	= Operating.
av	= Mean or average.	p	= Pump.
max	= Maximum.	s	= System.

atmospheric pressure. More interesting than the speed of a pump is its capacity which has only recently been given recognition in manufacturers' data.* From a plot of the type of Fig. 1 for speed, the capacity is determined by multiplying the speed by the pressure at which this speed obtains. When capacity vs. log pressure is plotted as in Fig. 2, then it is simple to predict the operating pressure P_o, at the inlet of the pump which results for any given process capacity Q. In this chart the solid curve represents capacity of the system, and the dotted curve shows the compression capacity of the vapor pump itself. This latter is derived by subtracting the measured capacity of the backing pump and foreline from that of the system. At P_{max} the vapor pump is no longer doing any useful work of compression. Above this pressure it represents an added resistance or impedance in the system.

In Fig. 3 this corrected capacity curve is shown mismatched with a backing pump that is too small. The net system's speed under these conditions has a "negative resistance," such that there is a region of instability between A and B where the system will not stably maintain pressure. If the quantity of gas handled Q (corresponding to an operating pressure P_o) is gradually increased to a value of X (increasing the pressure to P_x), it will be found that a further slight increase to Y will cause a sudden jump of the pressure from P_x to P_y. The reason is that there is no capacity condition that will satisfy this in-leakage at any pressure lower than P_y. Likewise, if the gas quantity is now decreased to slightly below the value of Q, there will be a rapid decrease of pressure P_y back to P_x without intermediate stable equilibrium.

Once the system is designed to produce the desired pressure at the required gas handling rate, it is desirable to know how long it will take to pump down from atmospheric pressure to the desired value. The general equation for time of evacuation of a known volume, at a known exhaust speed between two pressures, is given by Eq. (5):[6]

$$t = (V/S) \log_e (P_1/P_2) \qquad (5)$$

Unless the speed is constant, constantly changing, or there is a known relationship between pressure and speed, it becomes necessary to summarize increments of time over which the conditions can be accurately predicted. The problem can be handled more easily by graphical means as shown in Fig. 4. Here the reciprocal speed (i.e., impedance, expressed as time per unit volume) is plotted against log pressure. It is possible in this way to plot reciprocal speed of each element in a system and then graphically to add the ordinate values to arrive at the reciprocal speed of the system. This follows directly from Eq. (2). The area under the final curve for the system can then be planimetered between any two pressures, and the result is related to the time of evacuation per unit volume for the system between those two pressures. A proper calibration factor, depending on the coordinate dimensions used must, of course, be used to convert the units of area to time per unit volume.

A chart of this type also has utility in predicting where "roughing" pump operations should cease and high vacuum valves should be opened. In Fig. 4 this is at a pressure X shown on the chart. At any pressure lower than this, a net increase of time results from continuing the roughing operation.

One troublesome problem that must not be overlooked in high vacuum design is out-gassing. In any high vacuum system the atmospheric gases, water vapor, etc., adsorbed by the construction materials of the system may be released during operation, especially at high temperatures, and thus add to the load of gas evolved by the process materials. The problem is not severe with cold construction materials until pressures of a few tenths of a millimeter are reached.

For lower pressures, however, and especially for cyclic operations where a time schedule is to be met, ample safety factors must be allowed. The subject has been dealt with extensively by Dushman.[5] However, the quantities of gas that may be released are so variable, depending on process temperatures and equipment design, that only previous experiment and experience can be relied on in estimating the extra pumping capacity necessary.

THE PROBLEM OF GAGING

A second problem, and one that is not always recognized, is the proper placement of gages which are necessary to infer process operating and control data. At higher pressures there is ordinarily no difficulty in this, but at micron pressures, quite a different situation holds. Although satisfactory gages are available,[8] nevertheless the gage reading is highly dependent on its proper location in the system as shown by Jacobs.[5]

This follows from a consideration of the motion of molecules at low pressures. In any fluid the molecules, of course, move in straight lines between collisions. Furthermore, there is a random distribution of directions after collisions. At high pressures, however, where the molecular mean free paths are short compared with the diameter of the conducting tube, the major molecular contacts are with other molecules, and there is a net streaming of the gas in viscous flow.

Under low pressures, when the molecular mean free paths are long, the major molecular contacts are with the confining wall, with equal probability of reflection in any direction. Hence, the speed of the pipe is determined by length and diameter and is independent of the pressure. These concepts exert an all-important influence, not only on the design of the system, but on gage location as well. The latter problem is one of finding a location in which the gage indication will be linearly proportional to the collision frequency of process molecules with the gas molecules of the system.

There are many incorrect ways in which a gage can be installed. The problem is difficult and seems to have no universal answer. A gage installed so that it can "see" a hot material in process, or a small leak in the reaction chamber, will read high because molecules from the hot material or the leak can stream into the gage. A gage installed with a nozzle pointing toward the pump may be subjected to a diffusion pump effect which will evacuate the gage below the pressure of the surroundings. On the other hand, a gage installed at any point in the system where gas tends to stream into it will read higher than the surroundings. Although the pressure so read will depend to some extent on the temperature of the shield and the type of gage,[7, 8] perhaps the best answer in most cases is to install the gage on the process chamber with its entrance baffled to prevent direct streaming. In any event, this problem is deserving of careful study in each installation.

* At the present writing the pump capacity as cataloged by manufacturers is a function of the foreline manifolding and the backing pump used on the calibration test. There is a movement afoot to present "compression capacity" characteristics that are independent of a particular backing pump. Thus the engineer will shortly find more universal design data on which he can base his system calculations.

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Compressibility in Gas Flow Problems

When gases or vapors are handled at high pressure drop, complex flow equations result and design is facilitated by charts

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Compressibility refers to the condition where the volume or density of a fluid depends on the pressure applied. In flow problems it is an appreciable factor only when vapors or gases are involved; liquids can generally be considered incompressible. The flow of a compressible fluid is further complicated by the fact that the density is also dependent on the fluid temperature. This in turn varies as the result of the flow, apart from any actual external addition or extraction of heat. Frequently, in design, due cognizance must be taken of special phenomena arising from the compressibility of the fluid. This applies to pipelines, pressure reduction lines, vents and process equipment handling vapors or gases at pressure drops which are large compared to the absolute pressure in the system.

Conventional methods of calculating pressure drop or capacity of fluid handling systems are usually employed for so-called incompressible fluids when the density is essentially constant throughout the system. Thus, in a strict sense, these methods are applicable only to the flow of liquids. For practical purposes, however, the incompressible flow equations can be used directly in flow of a compressible fluid if either: (1) The pressure drop in the system is less than approximately 20 percent of the system's absolute pressure; or (2) the pressure drop due to an increase in kinetic energy of the fluid is small compared to the over-all pressure drop. The latter is the case, for example, for flow through a pipe or conduit which is more than about 2,000 pipe diameters long. In either of these cases, the incompressible flow equations can be applied by using the arithmetic average pressure in the system as if an incompressible fluid were flowing at these conditions. In both cases the temperature of the fluid can be considered unchanged as the result of the flow. Of course, where the system contains heat exchange equipment, the temperature will vary accordingly and due allowance must be made.

COMPRESSIBILITY EFFECTS

As a gas flows down a pipe, its density decreases because of the drop in pressure. This results in an increase in gas velocity and kinetic energy. The unique properties of compressibility become evident only in cases where the increase in kinetic energy during flow through the system accounts for an appreciable portion of the pressure drop. It is this increase in kinetic energy that results in a decrease in temperature of the flowing gas or vapor. If the flow is to be kept isothermal, heat energy must be supplied to the fluid at a rate directly proportional to the rate of kinetic energy increase. It has been shown[3] that, in the absence of special heat exchange equipment, the flow through pipelines will be more nearly adiabatic than isothermal, even for very long unlagged lines.

The kinetic energy or velocity of the fluid may also impose a very direct limitation on the fluid handling capacity of a system. The velocity with which a pressure wave is propagated is the acoustic or sonic velocity:

$$c = (k\, g_c\, pv)^{1/2} = (k\, g_c\, RT/M)^{1/2} \qquad (1)$$

Once the fluid has attained sonic velocity, it cannot increase further in velocity by direct acceleration and conversion of pressure into kinetic energy. This is true because, by definition, pressure cannot be transmitted at velocities higher than the acoustic velocity. Additional conversion of pressure into kinetic energy is possible only by an increase in cross-section of the fluid conduit, so that further conversion of random molecular motion (or pressure) into directed kinetic energy can take place by reflection of molecules from the conduit walls, or by acceleration in a direction normal to the original flow.

The practical significance of this phenomenon is best illustrated by considering a system in which the upstream pressure is fixed. As the downstream pressure is reduced, the mass flow rate of gas through the system will increase until the linear gas velocity at some point in the system reaches the velocity of sound at that point. For a conduit of uniform cross-section, this limiting velocity will always occur at the discharge end of the line. A further reduction in downstream pressure will result in no further increase in mass flow rate through the system. Further increase in mass flow rate can be obtained by increasing upstream pressure. Reference works[1, 2, 6, 7] can be consulted for additional information on compressible flow phenomena.

COMPRESSIBLE FLOW THROUGH PIPES

The general equations for the flow of a compressible fluid through a pipe can be developed by an integration process combining Bernoulli's theorem, the Fanning friction factor equation, the equation of state for the gas, and the thermal conditions imposed on the system.[2, 4, 5] Since the final algebraic results are complex and incapable of expressing pressure drop as an explicit function of flow rate, the charts shown in Fig. 2 have been prepared for convenience in design.[5] These charts are intended primarily for estimating the pressure drop or gas handling capacity of an entire pipe system although, by proper manipulation, they can also be used for incremental estimates across a section of pipe. They have been prepared

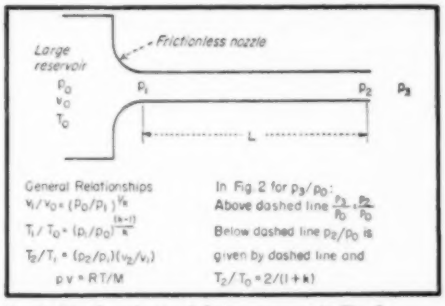

Fig. 1—Nozzle and pipe defining pressures in Fig. 2.

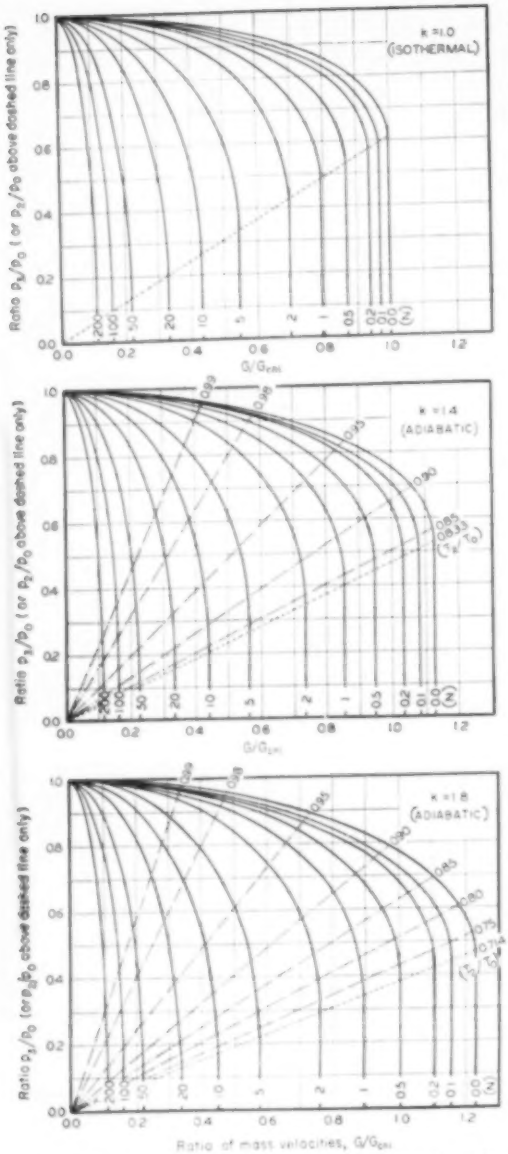

Fig. 2—Design charts for flow of gases or vapors through pipes at high pressure drop for k values from 1.0 to 1.8.

for values of the ratio of specific heats k of 1.0, 1.4, and 1.8. The chart for $k = 1.0$ corresponds to the adiabatic flow of a hypothetical gas (since no known gases have such a low ratio of specific heats), or to the isothermal flow of any gas (since the isothermal flow equations become identical with the adiabatic flow equations for a value of $k = 1.0$). For the adiabatic flow of gases with intermediate k values, interpolation may be used.

Values of k may be found in Ref. (5), p. 545. In general most high molecular weight organic compounds have a k value of about 1.1; C_2H_6, 1.2; CO_2, SO_2, H_2O, H_2S, NH_3, Cl_2, CH_4, C_2H_2 and C_6H_6 a value of 1.3; air, H_2, O_2, N_2, CO, NO and HCl a value of 1.4; and monatomic gases, 1.67. These values are for 1 atm. and 25 deg. C. Higher values generally result from a marked decrease in temperature or increase in pressure.

In the charts of Fig. 2 the ratio of downstream to upstream pressure, for straight horizontal pipe having a rounded frictionless inlet from a large upstream reservoir, is plotted against the flow rate referred to the flow G_{max} for a pipe of given resistance N*. The term G_{max} is the maximum possible discharge through a frictionless nozzle for isothermal flow from the specified upstream conditions:

$$G_{max} = \sqrt{g_c p_0 / v_0} = p_0 \sqrt{g_c M / RT_0} \quad (2)$$

While this flow cannot be realized physically, it has been employed as a rational, understandable, and convenient reference basis which permits the charts to be generalized for any upstream conditions.

The pipe resistance N is expressed in terms of the pipe length and the Fanning friction factor:

$$N = fL/m = 4fL/D \text{ for circular pipe} \quad (3)$$

The term N is essentially the friction loss through the pipe expressed as number of velocity heads (see Eq. 8, Lapple, p. 98, this issue). The curve for $N = 0$ gives the flow through a frictionless nozzle.

A limiting or maximum discharge rate is reached when the velocity in the end of the pipe attains that of sound. The pressure at which this limiting condition is reached is given by the dashed lines in Fig. 2. The various pressures are defined in Fig. 1. For values of p_s above the dashed line in the charts of Fig. 2, the pressure p_s inside the end of the pipe is equal to p_s. For values of p_s below the dashed line, the velocity in the end of the pipe will be that of sound and the pressure p_s will correspond to that given by the dashed line. Regardless of how much further p_s is reduced, p_s will not change nor will the discharge rate increase.

The dot-dash lines give gas temperature in the end of the pipe as a ratio to the initial temperature. The temperature T_s should not be confused with T_2. The drop in temperature from T_0 to T_s for adiabatic flow is due entirely to the increase in kinetic energy of the gas, regardless of the frictional effects that may be present. In adiabatic flow through a pipe into a much larger pipe or reservoir, the value of T_s will be substantially equal to T_0, except for the Joule-Thomson effect, even though T_s may be considerably lower. This is because of the conversion of kinetic energy back into heat as the fluid expands from the small to the large pipe.

APPLICATION TO DESIGN

In order to use the charts, it is necessary to know the friction factor f, in addition to pipe length, in order to determine the value of N. The friction factor for compressible flow is essentially the same as for incompressible flow and can be determined from the Reynolds number N_R, by means of a suitable friction factor chart (see Fig. 2, Lapple, p. 99, this issue). It is sufficiently accurate to

* In deriving the equation upon which Fig. 2 is based, it was assumed: (1) that the perfect gas law applies, (2) that the friction factor is constant along the whole length of the pipe for a given flow rate and pipe diameter, and (3) that the pipe is horizontal. Except for very high pressure work, the assumption of the perfect gas law $pv = RT/M$ is sufficiently accurate for most engineering calculations. Even where deviations from the perfect gas law occur, these can be allowed for in most cases by selecting an effective value of the gas constant R. The friction factor is a function of the Reynolds number DG/μ. The only variation in f along the pipe is that due to a change in viscosity, resulting from the gas temperature variation. This will amount to only a few percent. In practice, the effect on flow or pressure drop due to changes in elevation will be of relatively negligible magnitude for cases where compressibility effects are encountered.

Nomenclature

(Any consistent system of units)

- c = Acoustic velocity, ft./sec.
- D = Inside diameter of circular pipe, ft.
- e = Natural logarithmic base, = 2.718 . . . , dimensionless.
- f = Fanning friction factor, dimensionless.
- g_c = Conversion factor, 32.17 (lb. mass/lb. force) (ft./sec.^{2}).
- G = Mass velocity of fluid, lb./(sec.) (sq. ft.).
- G_o = Maximum mass velocity of fluid, lb./(sec.) (sq. ft.).
- G_{max} = Maximum mass velocity for isothermal expansion of fluid through a frictionless nozzle (See Eq. 2), lb./(sec.) (sq. ft.).
- k = ratio of specific heat at constant pressure to specific heat at constant volume, dimensionless.
- L = Length of straight pipe, ft.
- m = Hydraulic radius of pipe, ft. = cross-sectional area of fluid stream/"wetted" perimeter; = $D/4$ for circular pipe.
- M = Molecular weight of fluid, lb./lb. mol.
- N = Resistance factor = fL/m; = $4fL/D$ for circular pipe, dimensionless.
- N_{Re} = Reynolds number = $4m\ G/\mu$; = DG/μ for circular pipe, dimensionless.
- p = Absolute pressure of fluid, lb. force/sq. ft.
- R = Gas constant per mol = 1,546 ft.-lb. force/(lb. mol) (deg. F.)
- T = Absolute temperature of fluid, deg. F. abs. = deg. Rankine.
- v = Specific volume of fluid, cu. ft./lb.
- μ = Viscosity of fluid, lb./(sec.) (ft.) = 0.000672 × centipoises.

Subscripts

- 0 = In reservoir ahead of pipe.
- 1 = In throat of nozzle inlet.
- 2 = In pipe at exit of pipe or at any point, distance L downstream from throat of nozzle inlet.
- 3 = In reservoir into which pipe discharges.

use the upstream gas temperature as the basis for the viscosity used in the Reynolds number. If the flow rate is unknown (this usually being the desired quantity), the Reynolds number cannot be calculated and a trial-and-error solution is involved. Fortunately, however, the value of f does not vary over a very wide range (usually only from 0.003 to 0.004) in compressible flow applications, and the final solution is not very sensitive to the value of f. Consequently, a value of 0.0035 can be assumed for f to obtain N and a flow rate from the proper chart and curve of Fig. 2. This flow rate can be used to calculate the Reynolds number and thence the corresponding value of f. A repeat calculation of flow rate using this new value of f will generally give the final answer within a few percent.

While the curves of Fig. 2 apply to a straight pipe with a rounded frictionless inlet, they can be used for pipes containing abrupt inlets, bends, and other fittings by adding an appropriate value to the value of N, computed from the length of straight pipe, to obtain an effective value of N for use with Fig. 2. An abrupt inlet can be allowed for by adding 0.5 to the value of N computed for the pipe length alone. Fittings and valves may be allowed for by adding the appropriate friction loss, expressed as number of velocity heads, to the value of N (as given in Table II, Lapple, p. 98, this issue). However, where the fitting contains a contracted portion in which the cross-section is considerably less than that of the pipe, as in some valves, special analysis must be made since the contracted portion may be a controlling factor in determining the discharge rate. This is because sonic velocities may be attained in this portion before being attained in any other portion of the pipe. Fortunately, such cases are rare and will usually arise only for very short lines.

A comparison of the curves of Fig. 2 will show that, for a given pipeline and pressure differential, the mass discharge rate under adiabatic flow conditions will never be more than 20 percent greater than for isothermal flow conditions. The difference is greatest for short pipes. For pipes over about 1,000 pipe diameters long ($N > 10$), the discharge for adiabatic conditions will be less than 5 percent greater than for isothermal conditions.

For pipes of $N > 50$ (corresponding to pipes more than about 3,000 pipe diameters long), the maximum possible discharge rate is given within 6 percent or less by the following expression for either adiabatic or isothermal flow:

$$G_o/G_{max} = \sqrt{e/N} \tag{4}$$

or, by substitution for G_{max}:

$$G_o = \sqrt{g_c p_0/v_0 N} = p_0 \sqrt{g_c M/RT_0 N} \tag{5}$$

For pipes of N larger than 200, this approximation is accurate to better than 2 percent.

In vacuum condensers operating at pressures under 100 mm. Hg, the capacity of the condenser is sometimes limited by the maximum vapor that can be handled through the tubes for a given inlet (or column) pressure, rather than by the available heat transfer surface. This case is usually encountered when high molecular weight vapors are passed through condenser tubes which are too long in proportion to the total cross-sectional area of the tubes. In such cases, the heat transfer surface can be utilized most effectively by using more shorter tubes in parallel or possibly, if permissible, passing the vapors through the shell side. The curves of Fig. 2 can be utilized for evaluating such conditions.*

A Problem Solved

A reaction vessel designed for 100 psig. normally operates at 35 psig. and 65 deg. F. If the temperature rises to 100 deg. C., a decomposition occurs with almost explosive violence and CO gas is evolved. To relieve the pressure caused by such a decomposition a 6-in. Sch. 80 std. iron pipe, 23 ft. long, containing three std. 45-deg. ells, is provided as a vent. This pipe contains a lead rupture disk scored to break at 100 psig. What is the maximum possible rate of formation of CO gas which can be tolerated without exceeding the design pressure of the vessel? From the above we find that the various quantities involved in the calculation are: D = 5.761 in. I.D. = 0.480 ft. The pipe cross section inside = 0.181 sq. ft. M for CO = 28 and k as shown above = 1.4. T_0 = 100 deg. C. = 672 deg. F. abs. From Ref. (5), p. 791, μ = 0.021 cp. = 1.4 × 10^{-4} lb./sec. ft. Also, p_0 = 100 psig. = 16,500 lb. force/sq. ft. abs., and p_3 = 1 atm. = 2,120 lb. force/sq. ft. abs.

The problem may be calculated as follows: From Eq. (2) G_{max}^2 = (16,500)^2 × [32.17 × 28/(2.718 × 1.546 × 672)] and G_{max} = 295 lb./(sec.) (sq. ft.). From the conditions, p_3/p_0 = 2,120/16,500 = 0.128. The value of N for the straight pipe, from Eq. (3), = 4 × 0.0035 × 23/0.480 = 0.67 velocity heads. For the three ells (from Table II, Lapple, p. 98, this issue) N = 3 × 0.3 = 0.9, and for the abrupt inlet (as mentioned above) N = 0.5. N for the line is 0.67 + 0.9 + 0.5 = 2.07.

From the k = 1.4 chart of Fig. 2, with N = 2.07 and p_3/p_0 = 0.128, the value of G/G_{max} is found to be 0.730. Hence G = 0.730 × 295 = 215 lb./(sec.) (sq. ft.). Then N_{Re} = 0.480 × 215/(1.4 × 10^{-4}) = 7.32 × 10^4. This Reynolds number corresponds to f = 0.0031 (from Fig. 2, Lapple, p. 99, this issue). Repeating the calculation with f = 0.0031 yields N = 2.00, G/G_{max} = 0.737 and G = 218 lb./(sec.) (sq.ft.). The discharge rate is therefore 218 × 0.181 = 39.4 lb./sec., which is

* Such an evaluation will usually be conservative (and may be excessively so) as regards flow limitations because high molecular vapors near the condensation point may be associated so that the effective molecular weight is considerably greater than the formula weight. An outstanding example is acetic acid vapor. Unfortunately, insufficient data are available to make allowances for association in most cases. The actual amount of vapor handled by a given condenser may be greater than would be estimated from formula weight.

the rate corresponding to the maximum design pressure of the vessel.

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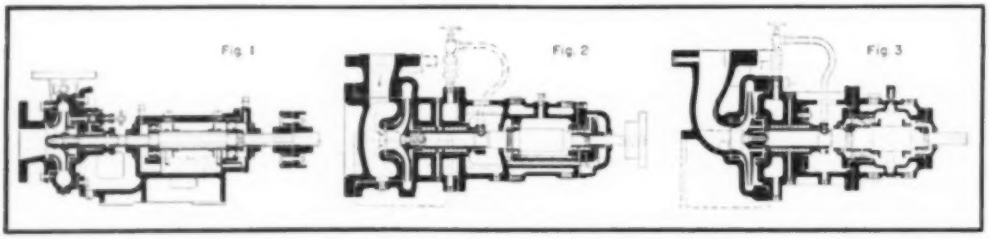

Centrifugal process pumps have developed from the type with overhung volute casing (1), to types with supported volute casing dismantled by removing a head (2), or dismantled from the inboard side without disconnecting piping (3).

Progress in Pumping Liquids

Definite trends in pump usage and design are becoming evident, bearing on the basic problems of suction, leakage and costs

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Today nearly all pumps offered for use in the process industries have been physically proved. There is seldom any question whether a pump is capable of delivering the required liquid from its discharge line, if all anticipated conditions of service are known to the supplier. Although the hydraulic performance may not be fully understood, it is sufficiently predictable, and both hydraulic and mechanical designs are at least workable.

There are, however, three basic problems which are the continual concern of users, designers, appliers and suppliers alike. These problems are: (1) "Getting and keeping sufficient suction"; (2) reducing and preventing leakage; and (3) reducing costs, including operating, maintenance and initial costs. The first problem is primarily that of having the pump induce full rated flow —continuously or irregularly—whenever the controls or instruments call for it. This "suction" problem also includes self-priming—or more properly, self-repriming—and may even involve continuous elimination of gas or vapor from the liquid being pumped. The second problem is obvious. On the third problem, the user may not be able to reduce these costs on pumps already installed, but he has them in mind for future units.

Actually, although the order in which these problems was mentioned is that of greatest importance, the principal advances in pumps have come about in the reverse order. This is not unnatural, since the tendency is always to work first on the obvious. Pump manufacturers cannot be blamed for having striven directly toward cost reduction and leakage reduction before discovering the importance of the suction problem.

Paradoxically, however, it may turn out that efforts on the less obvious suction problem will actually bring about larger savings in overall costs than the direct cost-reduction savings that have already been realized. As an example of savings resulting from improving suction performance (in the case of small centrifugal pumps anyway), certain new designs and new arrangements are on the verge of permitting partial elimination of pump houses, piping and vessel supports, as well as reduction in the necessary personnel in attendance.

TRENDS IN PUMP USE

Trends in the application, selection and arrangement of pumps can hardly be separated from trends in design, so intimately are they related. Still, it is possible to cite the most obvious departures from past practice.

1. Rotating pumps, including the centrifugal and rotary types as well as some hybrid "turbine-type" or peripheral pumps, are still tending to displace the older reciprocating types. In essence this is a trend away from pulsating flow to uninterrupted, continuous fluid flow, with the elimination of continuous valve action. (A similar trend away from cranks, rods and valves is continuing in the prime mover field and is taking place in compressors, too.) An important consequence of this trend is the use of smaller for larger and older equipment for the same service.

The trend toward centrifugal pumps will continue, particularly as process industries find need to handle lighter and lighter liquids, many near their boiling points. Rotary pumps also are continuing their invasion of reciprocating territory, primarily where viscous liquids are being pumped.

2. Among centrifugal pumps, there is a trend to make increasing use of vertical-shaft types for special services.

3. Increasing interest is evident in variable-capacity pumps and proportioning pumps. Many of these have automatic control features built into the pump or into the driver.

4. Improvements are evident in the use of pump combinations and piping arrangements. Among these we should note the use of separate booster pumps in conjunction with pumps which otherwise would have difficulty

in inducing full flow when supply tank levels are low. Also worth noting are the use of pump and jet combinations, and the growing tendency to avoid parallel operation of pumps, except where absolutely necessary.

TRENDS IN PUMP DESIGN

Reciprocating Pumps—With a few exceptions there has been little change in design in reciprocating pumps in 15 years. The largest sizes, those which used compounded steam ends or "crank and flywheel" steam drive, are no longer being offered, having lost the field to centrifugal pumps. Perhaps the most important advances concern variable-capacity power pumps and small proportioning pump designs. The variation of stroke length with constant motor speed has been accomplished in a number of ingenious ways. These arrangements usually lend themselves to automatic control, not only in the small proportioning feeders with fractional horsepower motors, but also on some of the large vertical triplex, high-pressure power pumps using motors up to and above 50 hp.

There is some evidence of advance in valves for the liquid ends of reciprocating pumps as a few makes are being marketed by others than pump manufacturers.

Centrifugal Pumps—At present and potentially these pumps are the most advanced. Their design trends will be discussed, in rough chronological order, primarily from the point of view of the basic problems.

COST REDUCTION

During the past 15 years a number of concrete achievements in cost reduction have come about—and not in initial cost alone. Among these we may mention:

1. Most 1,750-rpm. designs have been superseded some time ago by 3,550-rpm. pumps, except for low heads.

2. Many horizontally split casing designs have been superseded by vertically-split casings.

3. Among the so-called "process type" pumps, widely used in both refinery process service and in other process industries, an important series of changes has been going on. The type of single-stage pump with double-suction impeller in a central casing having two packingboxes between the bearings, has been superseded by pumps having an overhung single-suction impeller and only a single packingbox. Here the impeller is supported on a cantilever shaft and the casing is outboard of the bearings, as Fig. 1 indicates.

The next step in this design which initially had an overhung volute casing, bracket-mounted to the bearing-housing, was to make pumps having a saddle-mounted or centerline-supported volute, in which the impeller is overhung, as in Fig. 2. The design is thought to provide more strength against pipe strain and better alignments, especially for pumps handling hot liquids. More recently it has been applied to two-stage pumps also.

A still further development of this type came about in an effort to ease dismantling and maintenance procedures. Some pumps with the pedestal-supported outboard volute were first built with a large outboard head bolted on, for removal of the impeller. If these are called "outboard and inboard dismantling" types, their successors (Fig. 3) might be called "inboard dismantling only" types. With the added provision of a spacer spool in the coupling, the complete internal assembly and the bearing housing can be removed from the pump without disturbing the main piping or driver.

4. Horizontal centrifugal pumps for certain services are being superseded by vertical-shaft designs. There are at least three reasons: (*a*) For very low capacities and high pressures, multi-stage centrifugals can be built more satisfactorily with a vertical shaft. In fact, the number of stages that can be run in series on a vertical centrifugal pump is almost limitless. (*b*) Where the available suction head for a horizontal pump is insufficient or would require elevating the supply vessel, a vertical pump (as in Fig. 4) with its first-stage impeller near the bottom may be set in a hole, thus increasing the static suction head without elevating the supply vessel. (*c*) For pumping the more hazardous liquids, or those that must not leak at all, the vertical pump lends itself well to a "stuffing-boxless" design in which the driving motor is liquid-filled and has its shaft extend into the pump through a seal which keeps the liquids apart.

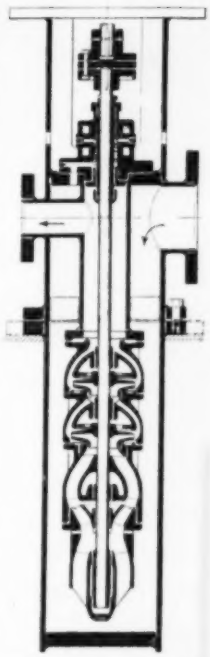

Fig. 4—Vertical centrifugal pumps solve NPSH problem by going down.

5. Further improvements in corrosion- and erosion-resisting centrifugal pumps are being introduced. Special materials for casings and wetted parts are now no novelty, especially in the chemical pump field. Slurry-handling designs are receiving more attention. Three approaches to the problem of abrasion resistance include the use of rubber-linings, abrasion-resisting materials, such as manganese steel, and pump arrangements which provide continuous flushing of clean liquid through the throat and clearance spaces.

6. Further than the speed increase already noted, since pumps operating at speeds above 4,000 rpm. have gained a foothold in the railroad and marine fields, they will soon make a dent in the process field for a variety of special services.

LEAKAGE PREVENTION

Effort toward the reduction or virtual prevention of leakage has, in comparatively recent years, brought about the development of mechanical seals. In the last 12 years there has been remarkable progress in this direction. Some seals were developed for light-duty water pumps and chemical pumps, but such devices really won attention when they were tried out in one of the most difficult packing services, the handling of liquid propane and similar light hydrocarbons. Here they achieved fair success from the start and further improvements were not long in the making. In this service, the circulation of gland oil through lantern rings had not worked out well enough. Although gland oil does increase the length of packing life in hot-oil pumps and some pumps for non-lubricating liquids, where it lubricates and cools the packing directly, gland oil had little success in postponing packing failures on liquids of low specific gravities at high vapor pressures.

There is still some division of opinion regarding the relative merits of single and double mechanical seals. The double seal, which faces both ways on a shaft, usually requires more in the way of auxiliaries and automatic controls, and so every effort has been made to perfect

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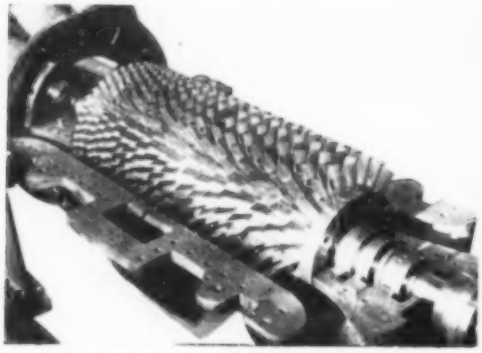

Fig. 1—Axial flow compressor (Westinghouse) is quite different in appearance from the centrifugal of Fig. 2.

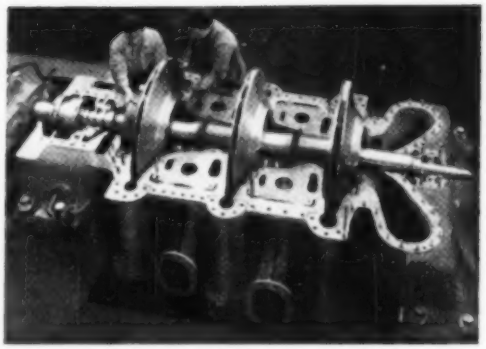

Fig. 2—High-efficiency centrifugal compressor (Oerlikon) discharges at four points around periphery as in Fig. 4.

Development of High Capacity Compression

Much progress is being made in both axial flow and centrifugal compressors for high-capacity, high-efficiency needs

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Compressed air in large quantities is required by many chemical industries. In most cases, it is supplied by conventional centrifugal compressors or by piston compressors. Both types are quite satisfactory in general, but their efficiency is relatively low (about 65 to 70 percent adiabatic efficiency), and the flow they can handle, although large, has definite limits.

Both in chemical and in mechanical engineering, there are processes which are possible only if large quantities of air or other gases can be provided at high pressure, with very high efficiencies. Sometimes the limiting factors are economic—as when a process cannot pay without cheap compression—and sometimes technical. For example, the gas turbine is a prime mover which depends on the supply of very large volumes of air at high pressure, with compression ratios from 4-to-1 up to 12-to-1. It is a differential power plant and its net power is the difference between the power supplied by the turbine and that absorbed by the compressor.

Consequently, both net power output and over-all efficiency of the gas turbine power plant are strongly affected by the efficiency of the compressor. If compressor efficiency falls below certain levels, no net power remains. The minimum permissible compressor efficiency varies with the maximum temperature and other factors, but even in the most favorable case, involving high temperatures and the use of heat exchangers, the adiabatic efficiences provided by conventional turbo-compressors are definitely not high enough for gas turbines.

As the gas turbine is a prime mover of great economic and military importance, in the last 20 years a considerable effort has been made, especially in Great Britain and in Switzerland, to develop types capable of giving really high efficiencies, well above 80 percent adiabatic. The problem was tackled from the aerodynamic side and theoretical work in fluid dynamics, and considerable expenditure in experiments enabled the goal to be reached over ten years ago. Since then the tremendous importance assumed by the gas turbine in jet propulsion for aircraft has given a great impulse to research and development in high-efficiency compressors.

Very considerable progress has been attained in the United States as well as in England and Switzerland. Granted that this development has been mainly directed toward perfecting the aircraft engine compressor, which is not directly applicable to industrial needs owing to its light weight, still, other types of high-efficiency machines brought out for industrial gas turbines can be used successfully as air or gas compressors in industry. It is well known that the first successful industrial gas turbine, the Brown-Boveri turbine applied to the Houdry catalytic cracking process, was used for a chemical process.[a]

AXIAL COMPRESSORS

Modern high-efficiency compressors are of two types: the axial and the centrifugal compressor. The first of these is essentially an inverted reaction turbine. The principle of such a machine is quite old. Sir Charles Parsons patented the idea over 60 years ago, and tried unsuccessfully to develop it 40 years ago.

Although an axial compressor and a reaction turbine are very similar in appearance, in reality the problems to be solved in the two machines are completely different. In the turbine, gas pressure is transformed into gas velocity, and the energy of motion of the gas is then converted to engine torque by suitable deviations of the fluid stream, which cause a change in the tangential component of the momentum of the fluid mass. The transformation of pressure to velocity is a natural process, which can be effected with great ease and excellent efficiency, even for considerable pressure and enthalpy drops.

In the axial compressor the situation is different. Here the rotative motion of the compressor blades impresses a high velocity on the fluid, and this velocity is then reduced and the energy of motion of the fluid is transformed to pressure. The operation of converting velocity into pressure is always difficult and is accompanied by notable losses.

This expresses the essential difference between turbine and axial compressor. Not only is the transformation of velocity into pressure bound with losses, but it is impossible to transform large variations of kinetic energy into pressure. Hence, reasonable efficiencies can be obtained only if the difference between the entering and the leaving velocity in each row of blades is small. Consequently, the pressure rise that can be obtained in each stage is small, and the axial compressor requires many stages to obtain a high pressure ratio. It needs many more stages than the corresponding reaction turbine will require to transform the same pressure ratio into rotative power at the same peripheral velocity. In general, it can be said that about four times as many stages is required by the axial compressor as for a reaction turbine which operates at the same pressure ratio and peripheral velocity.

As we have noted, current axial compressor designs have become possible through the understanding of modern fluid dynamics and aerodynamics. Different theories and methods were applied. In some cases long and careful experiments were made on profile grids, which correspond to a row of compressor blades. A theory was then developed to allow these test data to be applied to compressor design.[7] In other cases, each compressor blade was considered as a single aerodynamic profile or wing moving in an airstream. The theory developed for this case takes into account the fact that there are many blades relatively near each other.[8] Although these two theories appear to differ quite a lot, they really consider the same phenomena from different viewpoints, and can be deemed equivalent.

Calculations of axial compressors are further complicated by the fact that, in order to reduce the number of stages, peripheral velocities and airstream velocities are often very high. This is because the pressure rise per stage increases with the square of the peripheral velocity. When these velocities approach the speed of sound, compressibility effects appear with extremely bad consequences for efficiency and smooth running—difficulties which are similar to those met by aircraft flying at or near the velocity of sound.

Notwithstanding all these problems, the results now obtained with axial compressors are excellent, and would have appeared incredible 15 years ago. Over-all adiabatic efficiencies of over 85 percent are quite common, and there are large compressors working at 88 percent over-all adiabatic efficiency. An efficiency of 90 percent has been passed in experimental types, and there is no doubt that even higher efficiency figures will become usual within a few years. These figures must be compared with the 65 to 72 percent adiabatic efficiencies of conventional turbo-compressor groups. Obviously, the saving in power is extremely high.

At the same time, the number of stages required to reach a given compression ratio has been reduced. A few years ago, a ratio of 4 to 1 required about 20 stages; now it can be obtained with 9 stages or even fewer. A large reduction in number of stages is accompanied, however, by a fall in efficiency.

The axial compressor is small, light and compact, and is particularly apt to deal with extremely large volumes of air or other gases. For example, a 13,000-kw. gas turbine now working in Switzerland uses well over 100,000 cfm., while a 27,000-kw. turbine now being installed will need twice as much air at a very high compression ratio of 11 to 1. The axial compressor lends itself nicely to multi-stage design. There is little or no loss of efficiency and of space in passing from stage to stage. Some compressors have 20 stages in a single machine, although the trend now is toward fewer stages per machine. For high compression ratios intercoolers are placed between each 10- or 12-stage compressor.

This type of compressor is adapted to interesting and useful applications in chemical industries, owing to its compactness and extremely high efficiency. Its main defect lies in the fact that its characteristic curve is very steep—that is, small variations in volume imply large variations in pressure. Violent surging occurs if the flow volume is reduced beyond a well defined limit. For applications where either pressure or volume fluctuate, a variable-speed drive is necessary. Owing to their high speed of rotation, however, axial compressors are well suited to variable-speed drivers such as steam or gas turbines. Axial compressors, then, are excellent if large volumes of fluid are required. They are not particularly good for small volumes, below 6,000 cfm.

CENTRIFUGAL COMPRESSORS

The needs of the gas turbine have also brought considerable improvement to today's centrifugal compressor through the application of fluid dynamics methods.[3] For aviation purposes, single-stage centrifugal compressors giving compression ratios of nearly 4 to 1 and adiabatic efficiencies of over 80 percent have been brought out, while less extreme types, suitable for industrial gas turbines or for industrial air compressors, have been developed in Switzerland by the Machinenfabrik Oerlikon. Apart from general improvements in the design of the machine, these compressors have a characteristic feature; the diffuser spiral is divided into three or, more usually, four branches.[4]

It can be proved that this division of the diffuser spiral results in a considerable increase in efficiency. This occurs

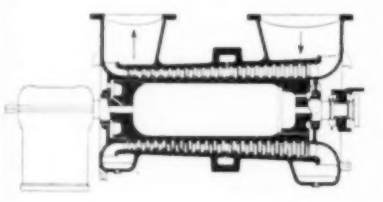

Fig. 3—Simplified cross-section of axial flow compressor similar to Fig. 1.

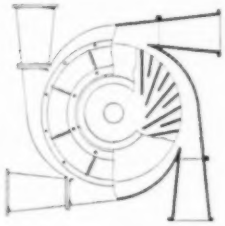

Fig. 4—Oerlikon centrifugal compressor showing multiple discharge points.

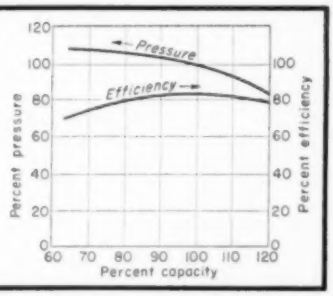

Fig. 5—Pressure and efficiency curves for Oerlikon compressor of Fig. 4.

because, owing to the smaller radial extension of each branch, the pressure differential in the diffuser pipe is considerably reduced. Oerlikon compressors with moderate peripheral speeds, suitable for industrial applications, give adiabatic efficiencies of 84 percent, a 4-to-1 compression ratio being obtained with three stages. Intercooling is incorporated compactly in the compressor, if desired. Recent developments tend toward higher peripheral speeds, so as to reduce the number of stages to two.

American firms interested in industrial gas turbines, notably the Elliott Co., are also active in high-efficiency centrifugal compressor work. The modern centrifugal compressor has a much flatter and therefore more favorable characteristic line than the axial compressor. Its efficiency is excellent, about 84 percent, but lower than that of the axial; it can deal with smaller volumes than the axial, but is less well adapted to extremely large flow rates.

It can be seen that present design of axial and centrifugal compressors have complementary qualities and defects. Both types undoubtedly will be called upon to give excellent service in industrial and chemical processes.

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Progress in Pumping Liquids

Continued from page 129

the single seal. Both types will probably survive. In both England and in the United States keen competition among new seal designs is promoting a healthy situation. Most of the centrifugal pump manufacturers have been drawn into the fray, either voluntarily, or by force of circumstances in the case of those who failed to see the relations of this basic problem to their own designs.

A valuable byproduct of the quest for good mechanical seals has been a considerable increase in the knowledge about conventional packing. All in all, the leakage-reduction job is becoming a little less art, a little more science.

THE PROBLEM OF SUCTION

Because centrifugal pumps have often had to draw liquid from a level below that of the pump, the priming problem has been obvious and has tended to draw attention away from the more basic problem of "net positive suction head." The NPSH problem, although formerly obscured by the emphasis on priming and flooding, is now coming to be appreciated. Many a pump has been able to secure suction initially by being primed, only to fail to maintain sufficient suction by its inability to *induce* flow at the required rates. Here NPSH is at fault, and better understanding suggests the cure.

In considering NPSH, it is important to note that the "net" means positive suction or inlet head over and above the vapor pressure of the liquid. The term is a useful simplified single measure of several concurrent conditions involved in the arrangement of suction line and vessel, the rate of flow, and the properties and temperature of the liquid being handled. Measured at the suction nozzle, or center line of the pump, it is the inlet head above vapor pressure, available under flow conditions. The pump designer can also convert a pump's ability to induce flow without cavitation into terms of NPSH required, for given rates or capacities. Since the values of NPSH available and NPSH required are easy to compare, fewer cases of cavitation are occurring today.

Pumps are being designed for full capacities at lower and lower values of NPSH but, of course, there are limits beyond which the designers cannot go.* Therefore, other methods for inducing full flow are of interest when these design limits are reached. Among these are larger sized pumps, elevation of vessels, use of vertical pumps set in holes, sub-cooling of the liquid, use of separate booster pumps, intermittent pressurizing of a lock-chamber in the suction line, as well as the essential reduction of all suction-line losses.

One bold new approach to the basic problem of NPSH is being made by the Nash Engineering Co. in its new Centrivac pump. Particularly suitable for handling non-homogeneous liquids or liquid-gas mixtures, this pump is not sensitive to marginal NPSH. It will, in fact, operate with NPSH values approaching zero. Unlike a normal centrifugal, it can handle a mixture containing as much as 50 percent gas or vapor by volume—with only 50 percent liquid—continuously delivering the gas and the liquid through separate discharge connections under required delivery pressures. Its action is continuous, as distinguished from the slugging of self-priming pumps.

Rotary Pumps—Design trends in the rotary pump field also should center around improvement of flow inducing, and here there is more chance for reducing losses inside the pumps themselves. Perhaps the most outstanding advance along these lines was made by Gulf Research & Development Co. under the guidance of R. J. S. Pigott. After testing and analyzing the various losses on many types of rotary pumps, this group recently brought forth startling improvements in the type of internal gear pump having "one tooth difference." Rearrangement of the inlet to the center of the gears, instead of at the periphery, enabled centrifugal force to aid rather than impede the incoming flow. Inclined rotating ports to ease the change of direction of liquid entering the gears also helped cut down the losses. Such pumps are being used at present for aircraft, but industrial applications may follow soon.

All rotary pump design problems are closely tied up with the adequacy of lubrication and clearances.

Turbine-Type Pumps—Pumps of the peripheral type have come into their own for a limited field of service during the last 12 years. In their range they are excellent on suction lift and for handling entrained gas, but are not as good as centrifugals for low NPSH. They take in and deliver any gas that comes along with the liquid, but when the vapor pressure is approached, their capacity is greatly reduced. It is their hybrid performance characteristic that fits them for a few applications better than either a centrifugal or a rotary pump.

Conclusions—For today, we may note that there is much current interest in centrifugal pumps of the stuffing-boxless type because they promise to solve both the problems of leakage and of cost reduction. The latter comes from the probability that they require less attention and less maintenance. For tomorrow, with further development on the basic problem of suction, it seems likely that many pumps will be located beside, or partly inside, the vessels from which they pump, thus enabling even greater overall savings to be realized.

* Although many users assume that the larger the eye area of an impeller, the lower the required NPSH, this is a hasty generalization. There is an optimum eye area, rather than a maximum, for best flow induction performance.

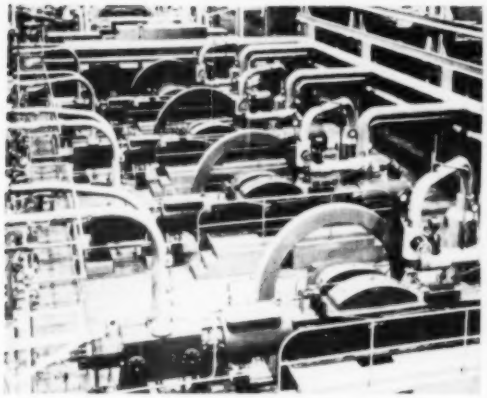


Fig. 1—These steam-driven recirculating compressors are operating at 5,000 psig. in an ammonia synthesis plant.

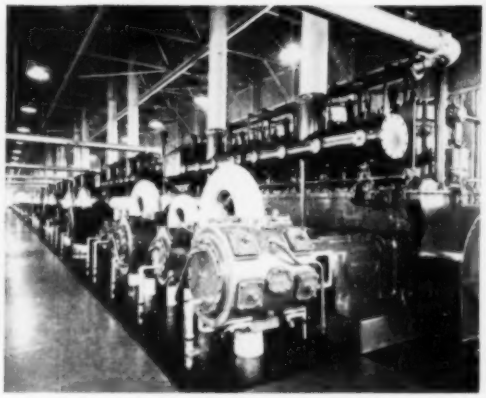


Fig. 2—Group of ten angle gas-engine-driven compressors, each rated at 1,000 bhp., in a southwestern chemical plant.

Process Pressures Forging Higher

Reciprocating compressors are responding to demands for higher speeds, greater compactness and higher pressures

H. M. BOTELER, Assistant Manager, Compressor Div., Worthington Pump & Machinery Corp., Buffalo, N. Y.

Rapid advances in chemical processing technique during and since the war have been a challenge to the inventive genius of compressor manufacturers and has heavily taxed their production facilities. The ever widening range of pressures and types of fluid to be handled presents new problems daily in the proper application of compression equipment.

Reciprocating compressors may be classified into three general groups including: (1) Standard designs for handling air and other inert, non-corrosive gases at moderate pressures; (2) Modifications of the first group, especially designed and built for a specific process requirement; and (3) Designs for high pressure. The first group comprises the manufacturers' stock and price list items. However, since the frames and running parts of these units are used also for compressors of the second and third groups, improvements made here benefit the other groups.

High land values and building costs have created a demand for more capacity in a smaller space. To meet this need existing compressor designs have been modified and improved to permit higher speeds. The result has been achieved through the use of more adequate pressure lubricating systems, metals with better wearing and physical qualities, improved valve flow characteristics, pistons of lighter weight construction, and more effective balancing to minimize inertia forces. General appearance of the conventional type horizontal machines has been greatly improved by streamlining wherever possible.

Relatively new high-speed, angle-type units, power driven at 500-600 rpm., are finding wider applications and greater general acceptance. This compressor uses an overhung shaft-mounted motor and has good running balance which reduces the foundation to a simple block of concrete for minimum installation time and expense. Motors for this type may be induction or synchronous design. An alternate drive arrangement is through a flexible coupling from practically any type of prime mover.

Chemical plant needs have tremendously increased the demand for units of the second classification. Applications for such compressors are steadily increasing. Process requirements are vastly more exacting now than they were a few years ago and the nature of the gases handled is far more complex. Methods of evaluating the compression characteristics of these complex gases have steadily improved. However, the lack of published data on specific heats, physical and critical constants of certain of the uncommon gases is sometimes a handicap. The problem will be with us until such information can be made more generally available.

Corrosion problems are ever present, and are accentuated in some of the newer processes. Selection of the most suitable materials of construction therefore is becoming increasingly important. The compressor manufacturer cannot guarantee his equipment against corrosion but he does attempt to suggest materials best suited from the over-all viewpoint of corrosion resistance, wearing qualities and obtainability. Close cooperation between manufacturer and purchaser is necessary, of course, for most satisfactory results.

MOISTURE'S BAD EFFECTS

Closely allied with the problem of corrosion within compressor cylinders is the effect of moisture or gas condensate. Many so-called corrosive gases are not corrosive at all, or only mildly so, when completely dry. Condensate within the cylinder therefore plays a dual destructive role. It not only tends to wash away the lubrication essential for long life of rubbing surfaces, but it also exposes these de-oiled, highly polished surfaces to attack by a gas made corrosive by the presence of condensate.

Many operators have received surprisingly large dividends from the use of adequate separators at compressor cylinder inlets. Separators to remove entrained liquid from the gas stream, plus a little extra expenditure to provide a

closed recirculating jacket-cooling-water system are well worth their cost. Liberal quantities of jacket water at a temperature well above the dewpoint of the gas at the cylinder inlet eliminates the wetness usually associated with readily condensable gases.

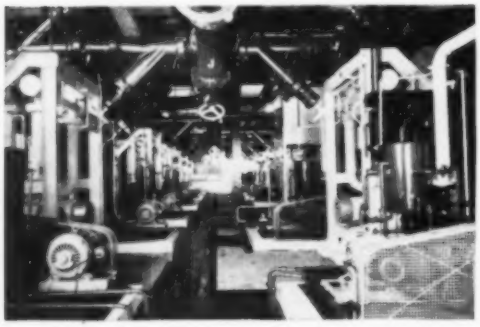
Synthesis plants operating at about 5,000 psi. grew rapidly in number during the war and increased the need for units of the third group. Most of these plants have now been converted to peacetime production of fertilizers and other chemicals and some have been expanded, requiring the duplication of existing equipment. Many recirculating compressors, as in Fig. 1, have been operating continuously, with only routine inspection and maintenance, since the early 1940's. Some went into operation at a much earlier date. American-made units have now completely supplanted those formerly made only in Germany.

Release of impounded foreign patents has focused attention particularly on the third group of compressors. There are several plants now under construction, mostly pilot installations, for producing synthetic fuels and chemicals. Pressures range from 5,000 to 15,000 psig. Fortunately, compressor design is keeping pace with this development. Furthermore, indications are that within the next few years there will be a marked increase in such requirements for compression equipment.

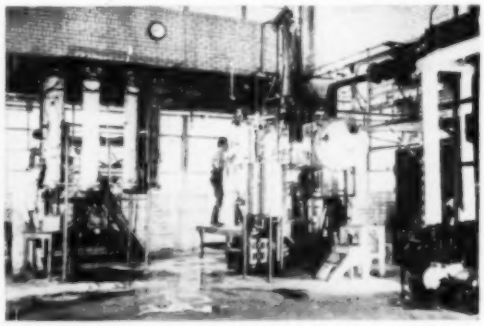
Among gas-engine-driven compressors, the trend has been toward larger, more compact units, again reflecting the need for more capacity in a smaller space. Angle-type units, in Fig. 2, have all but superseded the heavy, slow-speed horizontals. This trend has moved swiftly, angle units having first made their appearance in the early 1930's in sizes up to 300 hp. Late in that decade larger units developing up to 1,000 hp. came into general use. Development of still larger units was retarded during the war, but has steadily progressed since. Today units of 2,000 to 2,400 hp. are available.

Emphasis at present in these units is on improved thermal efficiency. Higher compression, more complete scavenging of burned gases, and greater spark intensity, have reduced fuel consumption by 15 percent, and further reduction seems possible and probable. Fuel costs, and often the lack of suitable gas in certain sections of the country, have heretofore restricted gas engine use in some localities. However, expanded pipeline facilities should tend to make application of angle gas-engine units more wide spread. The chemical industry, it should be noted, is using such units in increasing volume.

Although it can be expected that centrifugal compressors may eventually outmode the reciprocating type for many of the future installations involving large capacities and moderate pressures, still, the need for reciprocating machines is assured for many years to come. This is especially true in process industries where the inherent characteristics of the reciprocating machine will continue in demand for a wide range of capacity control and moderate volumes at relatively high pressures.



Vacuum dehydration unit in an English penicillin plant has 11 rotary condensers operating at —70 deg. F. and 2 microns. Capacity is over 100 lb. per hr. at 0.1 mm. total pressure.



National Research Corp.'s pilot plant for dehydrating coffee concentrates, showing extractors, moving belt dehydrator and brine absorption dryer for separation of water vapor load.

Trends in Vacuum Processing Equipment

Evaporative coating, dehydration, distillation and other processes are benefiting from improvement in vacuum techniques

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Through wartime necessity rapid advances occurred in high vacuum technology, as is now well known. Today we have large metal systems incorporating numerous valves, rotary seals and internal moving parts, operating successfully at pressures below 1 mm. Hg abs. The reason is not far to seek: Although the engineer in designing a process attempts if possible to utilize reactions which take place at or near atmospheric pressure, this ideal is impossible for many processes and high vacuum is necessary for one or more of several reasons. These may be summarized as follows:

1. At high vacuum the vaporization temperatures of materials are reduced, thus inhibiting thermal decomposition and simplifying selection of construction materials for reaction chambers.

2. The virtual absence of oxygen and other gases protects process materials from chemical decomposition and contamination.

3. The mean free path of gas molecules is higher at high vacuum, and vaporization and gas evolution rates are increased for given temperatures.

A high state of development of the basic components that go into high vacuum systems is responsible for the extent to which such processes are now used. In this field, where gases diffuse at low pressures, rather than flow in the usual sense, we must revise the classical flow concepts, both in the theory and in the design of efficient systems and equipment components. Fundamentally, all systems make use of reaction chambers, pumps, gages, and usually valves. Frequently a system will also require auxiliaries such as refrigerated traps, baffles, automatic controls and other instruments.

BASIC EQUIPMENT

Chambers—Generally the construction of vacuum chambers is in accordance with accepted practice for pressure vessels, although structural strength is not a prime consideration since pressures acting on the outside are small. Castings, if used, must be carefully inspected for porosity, and their use should be discouraged. One of the most troublesome phenomena of high vacuum is the ability to outgas possessed by most materials. Adsorbed gases on dirty or rough surfaces (such as rusty steel) increase the time required to attain low operating pressures. The presence of insulating materials which absorb gases and condensible vapors also results in long evacuation cycles and prevents attainment of sub-micron pressures. Gasketed joints must be smooth and flat so that a minimum amount of the gasket material is exposed to the inside of the vessel.

Pumps—For systems operating at pressures below 1 mm. Hg, mechanical pumps are generally used as a primary vacuum producer. Several manufacturers offer excellent rotary oil-sealed pumps ranging in capacity from a few liters per min. to several hundred cubic feet per min. The principal difficulty encountered in the operation of such units is the gradual accumulation of water and other condensibles in the oil. In effect, this raises the vapor pressure of the sealing medium to a point where it is impossible to attain low ultimate pressures. To remedy this trouble, continuous oil clarifiers are available, either as part of the pump for single installations or as separate units for connection to several pumps in multiple installations.

Carefully manufactured two-stage mechanical pumps using specially processed oil will attain ultimate pressures as low as 0.05 micron. However, their capacity is small—wholly inadequate to handle the large volumes which must be exhausted from metal systems to maintain low pressures against out-gassing of contaminated surfaces and inleakages of air. For this reason, diffusion pumps are commonly employed to boost the capacity of mechanical pumps. These jet type pumps utilize mercury or, more frequently, low-vapor-pressure oils. In one or more stages they compress the gas at the pressure of the chamber to a higher value such that the mechanical pump can operate in a higher and hence more efficient range.

DIFFUSION PUMP CHARACTERISTICS

Depending on the type of service, the engineer has considerable choice in the operating characteristics of the diffusion pump he may want to use. Booster type pumps which attain maximum speeds at 300 microns are available for dehydration and distillation operations. Other pumps peaking at pressures of 1 micron or below are useful in applications where the highest pumping speeds are needed to attain ultimate pressures of a fraction of a micron.

For producing pressures below 1×10^{-6} mm, it is generally considered necessary to provide a water-cooled or refrigerated baffle to prevent diffusion of pump oil vapor back into the system. In many cases the baffle may be eliminated, thanks to the development of fractionating or purifying diffusion pumps. In this design the low-boiling fractions of the pumping fluid are either trapped in the foreline or otherwise prevented from reaching the first stage jet. Pressures of the order of 1×10^{-7} mm. have been observed with all-metal purifying pumps, using an untrapped ionization gage for measurement.

Gages—In measuring pressures below 1 mm., bourdon tube or bellow gages are of no value. Precision manometers may be used in the region of 1 mm., but variations of liquid levels are minute and difficult to read.

Several very serviceable vacuum gages utilizing the principles of thermal conductivity of gases are available for pressures between 1 and 1,000 microns. Inexpensive, they are quite durable when equipped with metal envelopes.

Pressures below 1 micron are generally measured with hot-filament ionization gages which are constructed of glass and require careful handling. They cannot be exposed to pressures above 1 micron when in operation because of danger of burning out the filament. This latter objection is partially eliminated by the self-protecting feature incorporated in most control circuits to shut down the gage automatically in the event of too much increase in pressure.

A unique gage of recent design employs the ionization principle, but depends upon a radioactive source of alpha particles instead of a hot-filament electron source. This unit has a range of 1 micron to 10 mm. and is undamaged if exposed to atmospheric pressure.

Valves—The problem of constructing and maintaining systems which may be evacuated to pressures in the micron range is most easily understood by considering the tremendous pressure differentials involved. Leakage of 1 cu. ft. of air at atmospheric pressure into a system operating at 1 micron necessitates removal of 760,000 cu.ft. of air to maintain the internal pressure. For this service the ordinary packed-stem type of valve is out of the question. Diaphragm or bellows type valves offer the most effective solution to this problem. For systems operating at sub-micron pressures rubber diaphragms are not feasible because of the large area which would out-gas. Metallic diaphragms are limited in amplitude of deflection, making their use feasible only in the smaller sizes. Large valves, such as generally used in vacuum piping, must utilize metallic bellows.

Lubricated plug valves and quick acting types with specially designed seals have met with success where a certain amount of lubricant or rubber can be tolerated.

HIGH-VACUUM APPLICATIONS

The principal types of process to which high vacuum is being applied include coating, dehydration, distillation and metallurgy. Vacuum coating techniques are being used in evaporating films of molecular thickness on to lenses, and in making front-surface aluminum coated mirrors for high reflectance without refraction. Plastics are being coated with aluminum to simulate metal. A recently developed continuous coating machine is capable of coating flexible materials at several hundred feet per min.

An important high vacuum application is the drying of heat-sensitive materials by evaporating moisture from the frozen material. Except where cheap steam is available, the cost of operating multi-stage ejectors for this purpose is usually prohibitive. Huge volumes of water vapor must be handled and relatively low operating costs have been achieved with continuously scraped rotating refrigerated condensers which leave little vapor for the diffusion pump to handle. For smaller batches the familiar cabinet

type dryer with heated shelves is suitable, and for larger loads, rotary drum and moving belt units.

Closely related to dehydration is the distillation of high boiling compounds at partial air pressures of a few microns. Valuable materials such as vitamins are being treated in large stills having rotating conical evaporators with which the feed is in contact for the shortest possible time. The falling film type of high vacuum still is of more interest to the chemical industry because of higher throughput and comparatively low operating cost. Large units have been built for processing several tons per day at air pressures below 50 microns. Rates as high as 60 lb. per hr. per sq. ft. of evaporator surface have been observed on various ester type plasticizers. Possibilities of fractional distillation have been investigated and a unit now operating on a laboratory scale has effected 18-plate separations on binary mixtures at very small pressure drop. Plant scale equipment for fractional distillation under high vacuum should be a reality fairly soon.

High vacuum metallurgy has also been investigated actively and high vacuum reduction furnaces have been built for the light metals, magnesium, sodium and calcium. Vacuum muffles are being used for heat treating where bright surface must be maintained, and induction and arc furnaces for pressures below a micron are being used in removing impurities, alloying, and producing dense and sound ingots of both ferrous and non-ferrous metals. Vacuum sintering shows promise in improving the density, as well as the heat resistance and hardness of various metals.

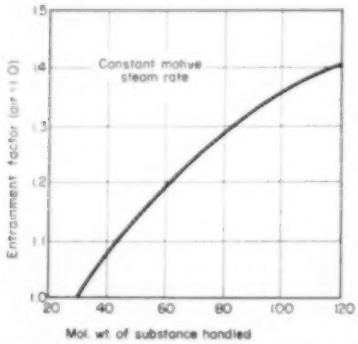

Fig. 1—How molecular weight affects ejector performance. Entrainment factor is a function of molecular weight.

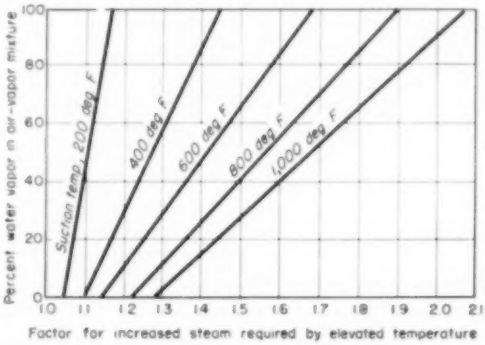
Percent water vapor in air-vapor mixture
Suction temp. 200 deg. F
400 deg. F
600 deg. F
800 deg. F
1,000 deg. F
Factor for increased steam required by elevated temperature

Fig. 2—How suction temperature affects steam consumption of ejectors for varying air-water-vapor compositions.

How Ejectors Are Developing

Although ejector design is largely empirical, compression efficiency is improving and field of use is becoming better understood

EDITORIAL STAFF

Steam jet ejector type vacuum pumps have come a long way since their debut at the beginning of the century, when they were first used to improve the performance of mechanical vacuum pumps on shipboard and in steam central station power use. At that time both their efficiency and their flexibility left much to be desired. At the outset only their low initial cost, and the fact that the heat of the motive steam could be recovered in the feedwater system, made them attractive enough to use at all. Now, however, within certain performance limits, they have become an important and widely used piece of equipment in chemical processing, as well as in other fields.

Here's how they developed. During the 1920's ejector design began to show signs of science and in this period ejectors became the principal vacuum pumping device in central station applications. A few manufacturers began making them for the industrial market, since their low cost and simplicity overshadowed uncertain performance and poor economy. In the next decade they stayed in the running and a rapidly expanding market led to a great many improvements in both economy and design. During the war years ejector use snowballed, with a phenomenal increase in the size of equipment and ultimate vacuum produced. Now, although they are still being improved in design, ejectors are being studied more critically by industry to determine their place in the vacuum field. This article will attempt to define the limits within which the ejector may prove to be the best all-around vacuum producer.

The advantages of ejectors over other vacuum producing devices include simplicity, low first cost, no moving parts, light weight, compactness, and easily obtained and installed repair parts. Also, little attention is required during operation, and they can compress condensible as well as non-condensible vapors. Then, too, ejectors can be built of both metallic and non-metallic acid-resistant materials. Finally, when properly applied, they operate at low cost.

And here are the disadvantages to be considered. An ejector is a fixed-load machine, always maintaining a fixed absolute suction pressure when a given load is applied. Its water requirements are higher than for other types of

Table I—Pounds per Hr. of Motive Steam to Compress 100 Lb. per Hr. of Dry Air With Single-Stage Ejector Unit.

Suct. Press., In. Hg Abs.	Motive Steam Pressure, Psig. 75	100	125	150	200	250	300	Mech. Pump, Cfm. Net*
4	680	575	550	525	505	495	480	470	167
6	495	425	405	385	370	365	350	340	111
8	275	245	235	225	220	215	207	200	84
10	225	200	190	180	175	170	163	155	67

* Net cfm. displacement required if mechanical vacuum pump is used. Net displacement = gross displacement x vol. effy.

Table II—Pounds per Hr. of Motive Steam to Compress 100 Lb. per Hr. of Dry Air, With Two-Stage Non-Condensing Unit.

Suct. Press., In. Hg Abs.	Motive Steam Pressure, Psig. 75	100	125	150	175	200	250	300	Mech. Pump, Cfm. Net*
0.5	5,000	3,850	3,625	3,350	3,150	3,000	2,850	2,750	1,340
1.0	2,000	1,650	1,500	1,410	1,340	1,290	1,210	1,180	670
1.5	1,470	1,250	1,125	1,040	980	930	890	850	446
2.0	1,100	950	870	970	755	725	690	660	335
3.0	800	675	625	580	555	540	515	500	222

* See note Table I.

Table III—Pounds per Hr. of Motive Steam and Gpm. of Condenser Water to Compress 100 Lb. per Hr. of Dry Air, With Two-Stage Unit With Jet Inter-Condenser.

(Condenser water at 70 deg. F., motive steam at various pressures.)

Suct. Press., In. Hg Abs.	Motive Steam Pressure, Psig. 75 Lb./Hr.	Gpm.	100 Lb./Hr.	Gpm.	125 Lb./Hr.	Gpm.	150 Lb./Hr.	Gpm.	175 Lb./Hr.	Gpm.	200 Lb./Hr.	Gpm.
0.5	1,100	35	980	30	940	28	900	27	870	27	845	26
1.0	675	23	600	20	575	19	550	18	535	18	520	17
1.5	550	14	490	12	470	12	450	11	435	10	420	10
2.0	450	13	400	12	385	11	365	10	355	9	345	9
3.0	365	11	325	10	310	10	300	9	290	9	280	9

Table IV—Pounds per Hr. of Motive Steam and Gpm. of Condensing Water to Compress 100 Lb. per Hr. of Air-Water-Vapor Mixtures, Two-Stage Unit With Jet Inter-Condenser.

(Motive steam at 150 psig., condensing water at 70 deg. C.)

Suct. Press., In. Hg Abs.	Composition of Mixture, 100 Lb. Total, Ratio Air to Water Vapor—100 Lb. Air—70 Air 30 Water—30 Air 70 Water— Lb./Hr.	Gpm.	Cfm.*	Lb./Hr.	Gpm.	Cfm.*	Lb./Hr.	Gpm.	Cfm.*
0.5	900	27	1,340	750	24	1,580	475	22	1,940
1.0	550	18	670	450	16	780	315	15	957
1.5	450	11	446	375	10	521	250	9	638
2.0	365	10	335	315	9	390	225	8	478
3.0	300	9	222	250	8	260	175	8	319

* Required mechanical pump net displacement, see note Table I.

Table V—Pounds per Hr. of Motive Steam and Gpm. of Condensing Water to Compress 10 Lb. per Hr. of Dry Air From Low Suction, Three-Stage Units With and Without Inter-Condensers.

(Motive steam at 150 psig., condensing water at 70 deg. F.)

Suct. Press., Mm. Hg Abs.†	Stages Condensing—None— Lb./Hr.	Gpm.	First Only— Lb./Hr.	Gpm.	Second Only— Lb./Hr.	Gpm.	1st & 2nd— Lb./Hr.	Gpm.	Mech. Pump, Cfm. Net*
2.5	950	325	10	200	20	140	16	675	
5.0	500	200	9	155	14	115	14	337	
10.0	290	145	8	110	8	80	12	169	

* See note Table I.
† Conversion factor, 1 mm. = 0.03937 in. Hg.

Table VI—Booster Ejector Performance

(Lb. per hr. motive steam to compress 1,000 lb. water vapor per hr. to 1.5 in. Hg abs.)

Suct. Press., Mm. Hg Abs.	Motive Steam, Psig. 50	100	150
2.0	15,000	10,000	9,500
4.0	5,000	3,600	3,400
6.0	3,250	2,300	2,150
8.0	2,400	1,700	1,600
10.0	1,850	1,300	1,225
12.7	1,400	1,000	940

vacuum producers, while its steam economy is poor at motive steam pressures below 100 psig. A drop in motive steam pressure below the design value seriously impairs the performance. Low loads are likely to cause instability, and moisture in the motive steam, erratic performance. It is extremely difficult to secure performance data on ejectors from the literature or other sources, with which to carry out preliminary investigations of the vacuum problem. Little has been published concerning theory and design.[6]

At present there is a better appreciation of the pros and cons of ejector selection than in the past, but mistakes are still common. The following suggestions should eliminate some of them. Don't specify steam pressures greater than can be maintained at the point of installation. Also, try not to specify an excessive factor of safety, since this tends to underload the ejector to the point where instability becomes more pronounced. (See, for example, Frencan.[1]) Other common mistakes include trying to operate an injector on wet steam; supplying incorrect quantities of water to the condensers, or water that is too warm; improperly specifying the quantities of condensible or non-condensible material to be compressed; and trying to change the load operating characteristics of the ejector by changing the motive steam pressure.

There are certain conditions which generally favor ejector use over other devices. Availability of steam at pressures greater than 100 psig., and of water at reasonable cost to serve inter-condensers, are two. An appreciable quantity of gas and vapor to be compressed, a relatively high percentage of condensible vapors in the load, the presence of corrosive materials, and the need for suction pressures between 5 in. and 100 microns Hg, are others. A suitable means for disposing of condensing water and exhaust steam is, of course, necessary.

The following considerations determine the type of ejector required: The absolute suction pressure desired; the amount of condensible vapor in the load; the desired discharge pressure; the value, if any, of the condensible portion of the load; the number of hours of operation per year; the relative cost of steam and water; the space and headroom available for installation; the motive steam pressure; and the available condensing water temperature.

The highest economic compression ratio for a single stage may be taken as 6:1 for relatively heavy duty, with 10: 1 the limit for lighter use. This rule is a rough criterion for determining the number of stages required. The necessity of using inter-condensers is contingent upon the size of the load, the operating cost, and fixed charges. In general, small loads and occasional operation favor the non-condensing type of unit. The value of the condensate and installation considerations tend to dictate whether surface or direct contact condenser should be used.

Although performance figures are difficult to obtain, a few data have been assembled from various sources and are presented in the accompanying tables. They are believed to represent good averages of current ejector practice, assuming stable operation.

Table I, for non-condensing, single-stage ejectors, shows the advantage of operating with motive steam pressures of 100 psig. or more, and indicates the rapid increase in steam consumption at lower pressures. Table II, for non-condensing two-stage units, indicates similar trends in steam consumption and suction pressures. Although single-stage units are often used at suction pressures as low as 2 in.

Hg abs. when first cost is the main consideration, two-stage units are more economical below 4 in. Hg abs. Both tables show the net displacement that would be required for the same load and suction pressures if a mechanical pump were used. (Note that net displacement is gross displacement times volumetric efficiency.) For the lower pressures of Table II, it is evident that a considerable mechanical pump displacement would be needed.

Effect of Intercondensers

The effect of using a jet inter-condenser with a two-stage unit for the same service as Table II is shown in Table III. There is a marked reduction in steam cost, which is not offset by the small quantity of cooling water used. If surface condensers should be used instead of direct-contact jet condensers, steam usage would increase by 3 to 10 percent. The effect of compressing a mixture of water vapor and dry air for the same total load as in earlier tables is shown in Table IV. This table emphasizes the weight handling characteristics of the ejector, in contrast to the volume handling characteristics of the mechanical vacuum pump. As the percentage of water vapor increases for a constant total load and suction pressure, the steam and water requirements of the ejector decrease, whereas the pump displacement increases, requiring a larger pump.

In Table V consideration is given to the use of three ejector stages with and without inter-condensers. The figures here are somewhat approximate as it has been necessary to reduce the available data to a common air load. Although the three-stage non-condensing unit requires high steam consumption, it has a definite place in the ejector field. It is lowest in first cost, produces no water drainage problem, and has the most rapid "pump-down" characteristic of all of the combinations listed. The second arrangement, with the first stage condensing and second stage non-condensing, shows a marked decrease in steam consumption, and has certain advantages of its own. First, it has fairly good "pump-down" characteristics. Second, when used with a surface inter-condenser, this scheme produces a condensate less contaminated with water than the other units. It is widely used when the condensate has money value and is condensible at a condenser pressure of around 1.5 in. Hg abs.

Four- and five-stage ejectors have been built in large sizes for such uses as drying blood plasma and penicillin, processing vitamins, and producing magnesium by the ferrosilicon process. However, these units are expensive to operate, their performance is difficult to measure with existing gages, and they require absolutely dry steam for operation. Available performance data in this range are erratic and there appears to be a trend away from ejectors for the lowest pressures. Instead, zero clearance rotary pumps and diffusion pumps are apparently giving better results and in this field ejectors are now being used only where the size of other devices is prohibitive. Most new processes, in fact, are trying to avoid the need for high capacity vacuum devices at very low absolute pressures.

Thus far we have discussed ejectors only in their capacity as vacuum pumps. They are also used extensively as thermocompressors and boosters. The term booster is commonly applied to an ejector stage designed to compress large quantities of water vapor or other condensible substances from relatively low absolute suction pressures to a discharge pressure at which the vapors can readily be condensed with available condensing water. A thermocompressor is an ejector stage designed to compress large quantities of vapor from a suction pressure at or near atmospheric to a discharge above atmospheric. It is used primarily as a heat pump.

Although they have been used for years to recover waste heat, very few performance data are available on thermocompressors. It is probable that that sort of equipment would be much more widely used in the process industries if its capabilities were better known. The recent rash of articles on heat pumps almost totally ignores the thermocompressor. Conditions conducive to its use include an ample supply of waste heat at a pressure below use value, requirements for steam at a pressure not more than three times the absolute pressure of the exhaust steam, and motive steam available at a pressure in excess of three times the absolute intermediate pressure. For more information see Refs. (2) and (6).

Boosters are widely used for large scale vacuum processes, and enable higher condensing water temperatures to be used. Generally associated with steam jet vacuum refrigeration units,[7] on which only two or three companies are now concentrating, most boosters at present are being used in oil refineries, chemical plants and food processing plants, to compress stripping steam to a pressure at which it may be readily condensed. It is quite usual to find units compressing 2,-3,000 lb. of stripping steam per hr. from 2 mm.-0.75 in. Hg abs., to discharge pressures of 1.5-2.5 in. Hg abs. The centrifugal compressor—a very expensive device—is the only other type compressor that is capable of handling these large volumes. It has the advantage of requiring less condensing water than a booster.

Table VI is believed to be representative of present-day booster performance. Looked at another way, a booster using 150 psig. motive steam to compress 1,000 lb. per hr. water vapor from 10 mm. Hg abs., will consume 1,000 lb. of steam per hr. in compressing to 1.25 in. Hg abs. condenser pressure; 1,225 lb. to 1.5 in.; 1,500 lb. to 1.75 in.; and 1,750 lb. to 2.0 in. Hg abs.

Data on boosters handling substances other than water vapor or air, or handling substances at elevated temperatures, are very limited. The only information published so far on the effect of molecular weight on performance is that of Work and Haedrich,[8] from which Fig. 1 is taken. Here the entrainment factor is the relative weight of material handled compared with air, for a constant motive steam rate. The only data published on effect of elevated-temperature ejector entrainment are those of Freneau[1] and Freneau, Kelso and Hoge[2] which appear in Fig. 2.

Predictions on the future trends in ejectors run about as follows: Increased dissemination of information about ejectors by manufacturers, universities and research organizations will make possible more intelligent selection of units by buyers, resulting in fewer unsatisfactory installations. Keen competition and greater buying intelligence will continue to bring about improvements in selection and performance. The field of practical ejector use will become more closely defined. While ejectors may yield to somewhat more efficient devices for extremely high vacuum, they will continue to be the preferred machines for the "middle vacuum range" from 100 microns to 5 in. Hg abs. Chemically resistant designs may be expected to become even more common than at present.

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Producing Aliphatic Solvents

Reflecting increasing uses for narrow-boiling aliphatics, especially in the protective coating industry, Humble Oil has added three of these new solvents to its line of petroleum products

J. V. HIGHTOWER

At Baytown, Tex., Humble Oil & Refining Co. is producing aliphatic solvents of narrow boiling range to round out the line of petroleum solvents which the company has marketed. During the war Humble developed a 10 deg. xylene product and enlarged its line to include industrial grade toluene and other aromatic solvents of high purity after the war ended. The company is now manufacturing the narrow-boiling aliphatics.

The company's interest in this field is a reflection of the increasing use of these petroleum-based solvents. A growing outlet for petroleum solvents is the protective coating manufacturing industry, where total domestic production of such coatings amounted, in millions of gallons, to 280 in 1936, 400 in 1941 and 500 in 1946. Rubber goods manufacture, extraction of fats and oils and leather processing are other fields where these solvents are being used.

In order to supplement its older high-flash (300-400 deg. F.) solvents, the Baytown refinery is making three narrow boiling range products, and two wide cut products, all boiling below 300 deg. F. The narrow fractions, developed as companion products to the line of aromatic solvents, are designated as 10-deg. aliphatic solvents. The term indicates the maximum difference, in deg. C., between the ASTM initial boiling point and dry point. Individually, these solvents are identified as 10-deg. hexane, 10-deg. heptane and 10-deg. octane, which in each instance indicates the predominant normal hydrocarbon present. In addition, two aliphatic solvents having broader boiling ranges are being produced. These are designated as Solvent Naphtha No. 1 and Solvent Naphtha No. 7 (V. M. & P.).

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SOLVENT APPLICATIONS

With respect to principal applications of the aliphatic solvents, the hexane and heptane fractions are being used in the extraction of edible and inedible oils such as cottonseed, tung, soybean and corn as alternatives to the older pressure method of extraction. Also, an important use for heptane is in the cementing of rubber products, an application where another Humble product, Solvent Naphtha No. 1, finds an outlet. The octane finds use in the paint, varnish and lacquer industry because its boiling range, 225-240 deg. F., approximates the boiling point of toluene. Solvent Naphtha No. 7 (V. M. & P.) has applications similar to those of octane, and is used in rubber cementing, in the leather industry and in "shelf goods" paints.

After the war ended, Humble bought from the government the Baytown Ordnance Works, including the hydroforming equipment and related fractionating and extraction facilities used to manufacture nitration grade toluene during the war, and converted this equipment and other facilities to the production of aromatic solvents and improvement of the quality of motor fuels and burning oils. Today the company is producing a line of aromatic solvents which include toluene, a mixture of xylenes, and two heavier aromatic solvents, Solvesso 100 and Solvesso 150. Liquid sulphur dioxide is used to extract the lighter aromatics from concentrates fractionated from a portion of the hydroformer effluent, while precise fractionation is required to produce the heavier aromatics.

At Baytown, a portion of the toluene is being produced for use in the manufacture of protective coatings and explosives, while the remainder is used as a component of aviation gasoline. The three other aromatics are going largely into protective coatings. At present, the xylene mixture, which contains around 26 percent ortho xylene, is not being fractionated into its components.

The aliphatic solvents are produced by close fractionation of two types of charge stock, (1) a virgin naphtha stock boiling within the range of isopentane and 200 deg. F. and (2) the raffinates resulting from sulphur dioxide extraction of toluene and xylene hydroformates. The C_5-200 charge stock, which is a doctor-sweetened straight-run material consisting largely of paraffins and naphthenes, serves as the source of Solvent Naphtha No. 1 and 10-deg. hexane, while the raffinates (200-300 deg. F.) serve as the source of 10-deg. heptane, 10-deg. octane and Solvent Naphtha No. 7.

HEXANE MANUFACTURE

In the manufacture of the hexane solvent the C_5-200 charge stock is preheated with steam and pumped through a series of four towers of a "superfractionating" unit. The overhead vapors from two of the towers, consisting of isopentane and isohexane, are blended into aviation gasoline. Another aviation gasoline component, isoheptane, is removed from one of the lower trays of the fourth tower. Hexane solvent is the overhead from the fourth tower, and is condensed and pumped through a caustic wash drum to remove hydrogen sulphide. Hydrogen sulphide is present in the stream because of thermal decomposition, in the fired fractionator reboilers, of polysulphides

resulting from doctor sweetening of the basic charge stock. From the caustic drum the product is pumped through a Hoover sweetening system. Hexane solvent emerges from the sweetener as a finished product. The material is 60 to 70 percent *n*-hexane, the remainder approximating 10 percent isohexane, 20 percent methylcyclopentane and 6 percent benzene.

A portion of the C$_6$-200 charge stock is pumped through a Hoover sweetener in order to improve odor and then blended with toluene raffinate to produce Solvent Naphtha No. 1.

OTHER SOLVENTS

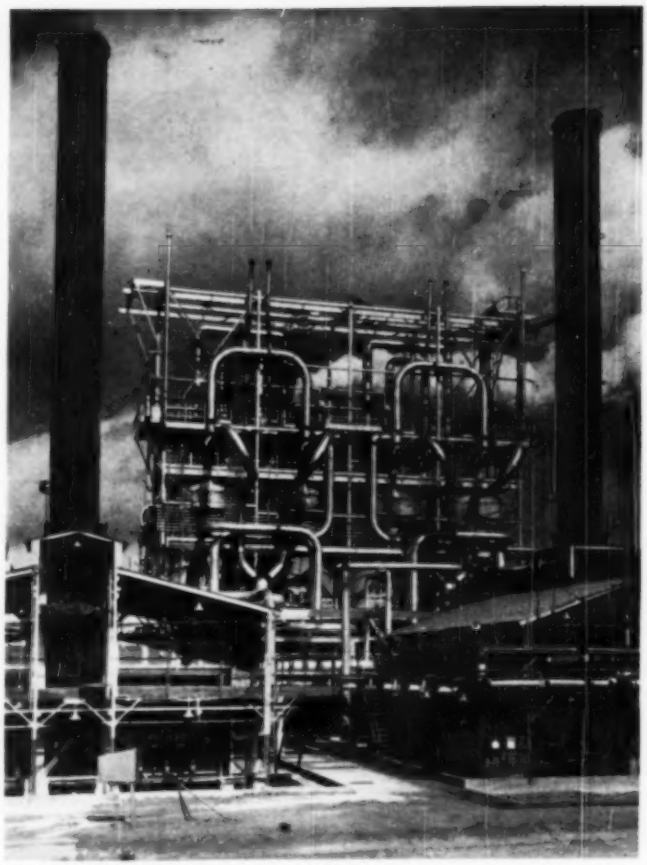
The heptane and octane solvents and Solvent Naphtha No. 7 (V. M. & P.) are manufactured from an 80-20 blend of the raffinates resulting from sulphur dioxide extraction during production of the toluene and xylene solvents. This material is accumulated in an 80,000-bbl. tank and after thorough mixing is pumped through a steam preheater and into a fractionator where the heptane vapors are removed overhead, condensed and sent to storage. Bottoms from the first fractionator are pumped into a second tower. The overhead from this tower is the octane solvent, and from one of the lower trays Solvent Naphtha No. 7 (V. M. & P.) is drawn off. The heptane product contains 50 to 60 percent *n*-heptane and methylcyclohexane. The octane solvent is a mixture of *n*-octane, isooctanes and naphthenes. Solvent Naphtha No. 7 (V. M. & P.) is a paraffin-naphthene mixture boiling in the range of 235-290 deg. F.

In the manufacture of the aromatic solvents at Baytown the type of charge stock put through the hydroformer (described in *Chem. Eng.*, Aug. 1944) determines the relative yields of the different aromatics. When toluene is the target, the preferred hydroformer charge is feed in the boiling range of 200-245 deg. F., in which C$_7$ naphthenes are dominant and which contains the toluene naturally present in the original crude. Xylenes are produced from a feed stock containing the C$_8$ naphthenes and which boils in the range of 245-300 deg. F. This also contains the naturally occurring xylenes. Solvesso 100 production comes principally from C$_8$ and C$_9$ naphthenes with a boiling range of 275-330 deg. F. Solvesso 150 is a product of side reaction on lighter naphthenes and is produced concurrently when making the other aromatics.

The fraction from the hydroformer products, which contains the aromatics is charged in series to four intermediate rerun fractionators. The first tower removes C-200 deg. F. fractions while the overhead products from the second, third and fourth towers, are, respectively, concentrates containing toluene, xylenes and Solvesso 100. Solvesso 150 concentrate is taken from one of the lower trays of the fourth tower. The percentages of aromatics in the four concentrates in the order named approximate 50, 60, 70 and 98.

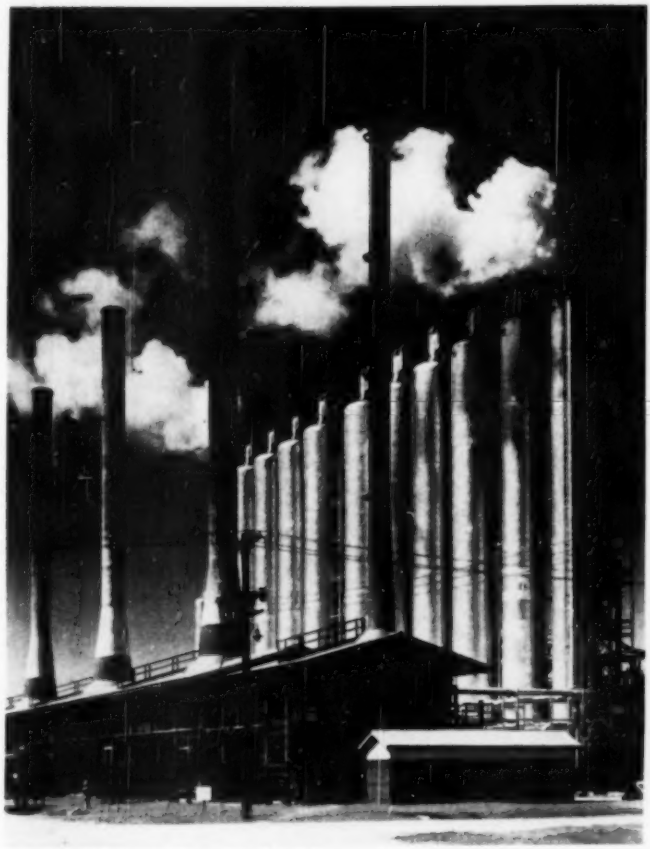
With the exception of Solvesso 150, which is already 98 percent aromatic, the concentrates are then individually extracted with liquid sulphur dioxide at sub-zero temperature in Edeleanu equipment, which Humble has modified in important respects. Each extracted aromatic solvent is then subjected to acid treatment, caustic washing and rerunning.

In the acid treatment the aromatics are throughly contacted with sulphuric acid for removal of olefins and diolefins. Fresh acid requirements run from 5 to 20 lb. of 98 percent acid per bbl., depending on the condition of the hydroformer catalyst. The acid treating equipment is more or less conventional. The product passes through an incorporator where it is mixed with recirculated acid, then through a settling drum for removal of sludge, then through a second incorporator with fresh acid, and finally into a combined settling drum and



HYDROFORMER used during the war for the manufacture of nitration-grade toluene, now produces raw materials used in the production of aromatic solvents.

Between them, these two pieces of equipment handle



FRACTIONATORS handle all distillation operations involved in production of solvents, including preparation of various types of hydroformer feed.

the major part of aromatic solvent production

coagulator where remaining small particles of sludge are coagulated on a gravel bed. Gravel is dumped once or twice a year.

The acid-treated products are next given a wash with 20 deg. Be. caustic solution at atmospheric temperature in order to remove traces of sulphuric acid. A second caustic treatment is necessary in order to remove sulphonic acids resulting from the acid treatment and which were not removed by the caustic at atmospheric temperature. To free the aromatics from such acids, they are preheated and pumped through a caustic hydrolyzer for contacting at 300 deg. F. with 20 deg. Be. caustic.

From the hydrolyzer the products are pumped into a rerun tower where small amounts of light hydrocarbons are removed overhead in order to bring the solvents to the required initial boiling point or flash point and to eliminate traces of water. Finished products are taken from a tray near the top of a 50-plate tower.

PRODUCT COMPOSITIONS

The toluene product approximates nitration grade in purity. The xylene solvent contains about 98 percent aromatics, and generally averages on the weight basis 17 percent ethyl benzene, 26 percent ortho xylene, 42 percent meta xylene and 15 percent para xylene. The Solvesso 100 approximates 95 wt. percent of C_9 and C_{10} aromatics. Solvesso 150 has around 98 percent aromatics boiling between 370 and 425 deg. F.

Yields of the aliphatic and aromatic solvents are subject to considerable variation depending on requirements. The company expects to be producing about 1,500 bbl. per day of the aliphatics during 1949. The C_6-200 charge stock which is normally processed contains, typically, 20 to 22 percent hexane solvent. The toluene-xylene raffinate normally yields 33 percent heptane, 17 percent octane and 45 percent Solvent Naphtha No. 7.

With respect to the aromatics, when the hydroformer is charging 25,000 bbl. per day the combined daily yield of the four aromatic fractions is approximately 8,000 bbl. of which only about 4,500 bbl. is being extracted and purified for solvent manufacture and other uses. The remainder is recovered as concentrates for special uses.

Humble has been fractionating at times from the C_6-200 charge stock small quantities of cyclohexane destined principally to a large chemical manufacturer interested in this material as an intermediate. In general the same superfractionating equipment used for the production of hexane solvent is employed, but a different piping arrangement is used. Cyclohexane production calls for a high degree of fractionation, accurate instruments and an extremely narrow range of temperature control. Liquid tray temperatures must be kept constant within 0.25 deg. F. in order to make a product meeting exacting specifications as to purity. A resistance thermometer type of control is used. As an indication of the importance of temperature, during a run when cyclohexane of 85 wt. percent purity was being produced, the temperature control got slightly out of adjustment and began controlling within 1.0 deg. F. As a result it was several days before specification product could be made. During the period the purity ranged from 78 to 89 percent. When control is within 0.25 deg. F., the purity range is 85 to 87 percent.

Great care is exercised to prevent contamination during the storage and handling of the solvents. All intermediate and final storage tankage is segregated. As a rule the solvents are handled over special loading lines and are shipped by tanker. Special compartments are allocated to each solvent, and no other product is placed in the compartment during the back haul. This avoids the chance of affecting the boiling range of the solvent when the compartment is next filled.

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REUBEN S. TOUR
University of Cincinnati, Cincinnati, Ohio
CHARLES HECKER
Clarkson College of Technology, Potsdam, N. Y.
THOMAS B. DREW
Columbia University, New York, N. Y.
ARTHUR H. RADASCH
Cooper Union, New York, N. Y.
FRED H. RHODES
Cornell University, Ithaca, N. Y.
ROBERT L. PIGFORD
University of Delaware, Newark, Del.
CHARLES G. DUNCOMBE
University of Detroit, Detroit, Mich.
WALTER H. BEISLER
University of Florida, Gainesville, Fla.
PAUL WEBER
Georgia Institute of Technology, Atlanta
J. HENRY RUSHTON
Illinois Institute of Technology, Chicago
H. FRASER JOHNSTONE
University of Illinois, Urbana, Ill.
GEORGE L. BRIDGER
Iowa State College, Ames, Iowa
GEORGE GLOCKLER
State University of Iowa, Iowa City, Iowa
DARRELL E. MACK
Lehigh University, Bethlehem, Pa.
PAUL M. HORTON
Louisiana State University, Baton Rouge
GORDON C. WILLIAMS
University of Louisville, Louisville, Ky.
WILBERT J. HUFF
University of Maryland, College Park, Md.
WALTER G. WHITMAN
Massachusetts Institute of Technology, Cambridge, Mass.
HENRY L. COLES
Michigan College of Mining and Technology, Houghton, Mich.
GEORGE GRANGER BROWN
University of Michigan, Ann Arbor, Mich.
CHARLES A. MANN
University of Minnesota, Minneapolis
JAMES R. LORAH
University of Missouri, Columbia, Mo.
LLOYD BERG
Montana State College, Bozeman, Mont.

Rules and Regulations Governing the Tenth Award
FOR CHEMICAL ENGINEERING ACHIEVEMENT

1. Purpose of this Award is to encourage a broader participation of the chemical engineer in the affairs of the process industries by giving public recognition to that company which through coordinated group effort has contributed most to the advance of the industry and profession. This Tenth Award will apply only to industrial developments that have come into commercial fruition or become publicly known since August 1945. All nominations must be received by August 1, 1949.

2. The Award will consist of an appropriate bronze plaque suitably engraved to indicate the nature of the achievement and the name of the company to which it is presented. The Award will be made at a dinner of the chemical engineering profession at the Waldorf Astoria Hotel in New York, the evening of December 1, 1949.

3. The Award is to be made to a company rather than to any individual within a company since it is primarily a recognition of group effort. However, any subsidiary or department within a corporate organization might be eligible for the Award on the basis of specific achievement brought to the attention of the Committee of Award.

4. The Committee of Award shall consist of the heads of chemical engineering in all of the educational institutions of the United States whose courses as of May 1, 1949, have been accredited by the American Institute of Chemical Engineers and the Engineers Council for Professional Development. Dr. Alfred H. White, Professor-Emeritus of Chemical Engineering at the University of Michigan and member of the Award Committee since its inception in 1933, will continue to serve as chairman. The editor of *Chemical Engineering* will continue as secretary, but without vote.

5. Any company in the process industries desiring to be considered for this Award is urged to submit, in confidence, the following data:
   (a) What is the nature of the achievement?
   (b) During what period has it come into commercial fruition?
   (c) To what extent have chemical engineers participated in its development?
   (d) Any supplementary records, data, articles or references which are pertinent to a fair consideration of this achievement and of the company's attitude toward its chemical engineers.

6. This Award is not restricted to those companies that file formal applications with the committee. Suggestions are desired from any and all sources that will assist the committee in directing attention to industrial groups that should have its consideration. Communications should be addressed to S. D. Kirkpatrick, Secretary, Committee of Award, Room 2400, 330 W. 42nd St., New York 18, N. Y.

ROBERT E. TREYBAL
New York University, New York, N. Y.
EDWARD M. SCHOENBORN
North Carolina State College, Raleigh
CHESTER P. BAKER
Northeastern University, Boston, Mass.
V. C. WILLIAMS
Northwestern University, Evanston, Ill.
JOSEPH H. KOFFOLT
Ohio State University, Columbus, Ohio
RICHARD L. HUNTINGTON
University of Oklahoma, Norman, Okla.
JESSE S. WALTON
Oregon State College, Corvallis, Ore.
DONALD S. CRYDER
Pennsylvania State College, State College, Pa.
MELVIN C. MOLSTAD
University of Pennsylvania, Philadelphia
JAMES COULL
University of Pittsburgh, Pittsburgh, Pa.
JOSEPH C. ELGIN
Princeton University, Princeton, N. J.
R. NORRIS SHREVE
Purdue University, Lafayette, Ind.
LEWIS S. COONLEY
Rensselaer Polytechnic Institute, Troy, N. Y.
ARTHUR J. HARTSOOK
The Rice Institute, Houston, Tex.
ORVILLE E. DRYER
University of Rochester, Rochester, N. Y.
CHARLES D. LUKE
Syracuse University, Syracuse, N. Y.
ROBERT M. BOARTS
University of Tennessee, Knoxville, Tenn.
KENNETH A. KOBE
University of Texas, Austin, Tex.

FOR THE TENTH AWARD FOR CHEMICAL ENGINEERING ACHIEVEMENT

Committee seeks your cooperation in selecting the corporate group in the process industries that has contributed most to the advance of chemical engineering in industry and profession

AGAIN, we seek your suggestions and advice in furthering a worthy project of our profession—the Tenth Award for Chemical Engineering Achievement. Next December, during the biennial Exposition of the Chemical Industries in New York City, some company in the process industries will receive this outstanding recognition of progress made possible by the coordinated group effort of its chemical engineers. Again, that selection is to be made by a Committee of Award under the chairmanship of Professor-Emeritus Alfred H. White, and comprised of the heads of all the departments of chemical engineering in the United States that have been accredited by the American Institute of Chemical Engineers and the Engineers Council for Professional Development.

Plans for this series of awards were first announced in this magazine in May 1933. In contrast to most medals and citations, this Award is given to a company rather than an individual because its primary purpose is to recognize group effort—particularly the achievements that result from teamwork between technology and management in a corporate organization. It has also served to focus public attention on those progressive companies that have encouraged their chemical engineers to participate broadly in all affairs of the process industries.

Prior to 1948 this Award was presented biennially. Last year this was changed to an annual basis because of the increasing tempo of postwar progress and the fact that so many important chemical engineering achievements were coming into commercial fruition. For this reason the committee has decided to continue, at least for another year, to set V-J Day as the beginning of the four-year period now under its consideration.

Previous recipients of this Award are shown in the accompanying list. An honor roll of their citations is available in an attractive bulletin which will be mailed you on request. All nominations must be in the secretary's hands by August 1, 1949. Address your communications to S. D. Kirkpatrick, Secretary, Committee of Award, Room 2400, 330 West 42nd St., New York 18, N. Y.

JAMES D. LINDSAY
A & M College of Texas, College Station, Tex.
FRANK C. VILBRANDT
Virginia Polytechnic Institute, Blacksburg, Va.
ROBERT M. HUBBARD
University of Virginia, Charlottesville, Va.
ROBERT W. MOULTON
University of Washington, Seattle, Wash.
LAWRENCE E. STOUT
Washington University, St. Louis, Mo.
W. A. KOEHLER
West Virginia University, Morgantown, W. Va.
OLAF A. HOUGEN
University of Wisconsin, Madison, Wis.
ERNEST D. WILSON
Worcester Polytechnic Institute, Worcester, Mass.
BARNETT F. DODGE
Yale University, New Haven, Conn.

★ ★ ★ COMPANIES PREVIOUSLY HONORED ★ ★ ★

1933

Carbide & Carbon Chemicals Corporation.
Synthetic aliphatic chemicals

1935

Organic Chemicals Dept., E. I. du Pont de Nemours & Co., Inc.
Synthetic rubber from acetylene, camphor from turpentine

1937

Monsanto Chemical Company.
Large-scale production of elemental phosphorus

1939

Standard Oil Development Company.
Aviation fuels and petrochemicals

1941

The Dow Chemical Company.
Magnesium from sea water

1943

The American Synthetic Rubber Industry.
A vitally essential wartime accomplishment

1945

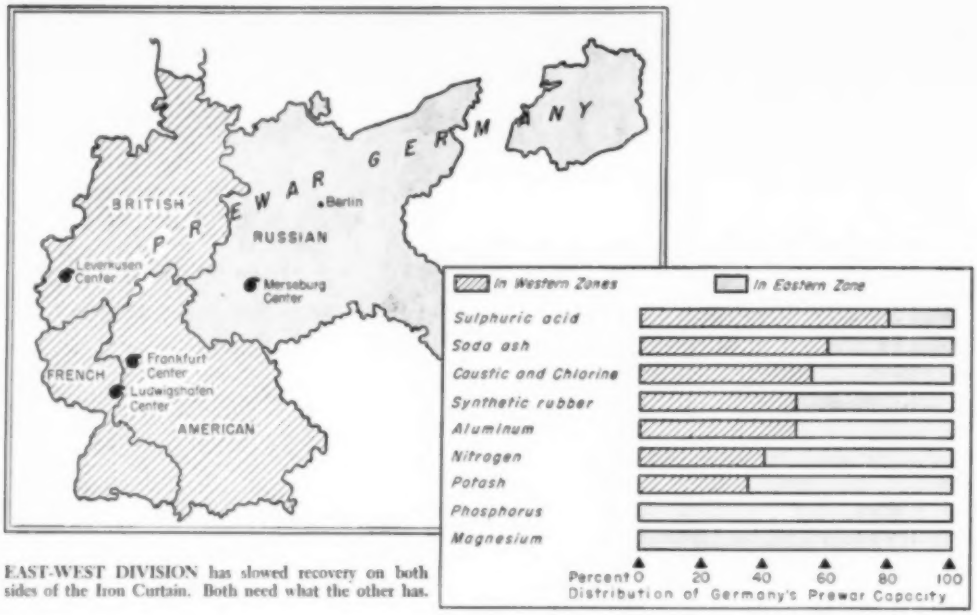
The Atomic Bomb Project.
War-ending achievement of science and industry

1947

Merck & Co., Inc.
Pioneering production of streptomycin and vital medicinals

1948

Shell Development Company.
Commercial synthesis of glycerine from petroleum



EAST-WEST DIVISION has slowed recovery on both sides of the Iron Curtain. Both need what the other has.

What Has Happened to Germany's Divided Chemical Industry?

Our former German correspondent, now professor of economics at Fresno State College, shows some of the effects of East-West separation—and opposing policies on reparations and reconstruction

KARL FALK

Germany's divided chemical industry has now reached the halfway mark. Its goal: to regain approximately 1936 capacity and output. It is a goal set by recent modifications in the Potsdam agreement. Recovery has been hampered by the virtual East-West separation of Germany since 1947, by divergent policies of the occupying powers, and by the breaking down of complex ownership, supply, producing, processing, and marketing relationships.

Destruction of Germany's war potential and compensation of Allies was originally the basis for limiting Germany's chemical industry. In the meantime, both the West and the East have reversed policy. The West, instead of breaking up the German chemical industry, is now supporting it as a key factor in German and European recovery. And in the East, the Soviet has stopped wholesale dismantling of plants and started to increase German production; their purpose is to get larger reparation deliveries to Russia and to support the Eastern European economy under Soviet control.

Two factors—war damage and postwar dismantling—have probably cost about half of Germany's prewar chemical capacity. War damage was heavier in the Western zones. Postwar dismantling—which destroyed at least twice as much capacity as the war—was heavier in the East.

Other factors have handicapped recovery almost more than capacity losses. One of these is Shortage—shortage of power, raw materials (especially coal, coke, and byproducts), machinery and equipment, packaging materials, and labor. A second handicap is Separation; zonal boundaries have severed plants from their customary fuel, power, and raw material sources, and have prevented the exchange of necessary raw materials and intermediate chemicals. A third difficulty is Reorganization; readjustments have been necessitated by changes in ownership and decentralization of for-

Dr. Karl Falk earned his doctorate at the University of Berlin and from 1932 to 1937 he covered Continental Europe for Chemical Engineering. *Since his return in 1938 he has been on the faculty of Fresno State College at Fresno, Calif. During the war he was chemical economist in the Department of Commerce and OSS.*

merly integrated units. (Although intended to result ultimately in increased competitive efficiency and lower prices, decentralization is tending, for the time being at least, to raise costs wherever the remaining plants have had to resort to self-sufficiency types of production.) And finally—loss of markets, lack of necessary imported raw materials, generally upset world conditions, and domestic and foreign trademark and patent uncertainties have also greatly hampered recovery.

On the positive side of the picture, some of the reorganization will probably prove healthy in the long run for Germany and the rest of the world. Dissolution of I. G. Farben, for example, will almost certainly result in more realistic prices and more balanced development in the future.

Immediate factors aiding recovery include the 1948 currency reforms in both areas, reestablishment of patent offices, new banking systems, improved transportation, improved coal supplies, and assigning of a key position to the chemical industry in manufacturing, agriculture, and export programs.

In the foreseeable future the German chemical industry, of course, cannot hope to regain its prewar position. Then it was the world's second largest chemical producer, supplying one-fifth the world output. It was the largest foreign trader in chemicals, accounting for one-fourth to one-third the world total chemical imports and exports. Nevertheless, it will still occupy an important place within the economies of the separate areas, and has been a leading, if not the chief, export supplier in foreign trade of the various zones since the war.

GEOGRAPHICAL DISTRIBUTION

It will be recalled that Germany's prewar chemical industry was based primarily on abundant supplies of coal, potash, limestone, and possibly wood and salt, somewhat unequally distributed between Western and Eastern Germany. The West enjoyed the advantage of having the major part of the hard coal supplies, and the East the major part of the potash and brown coal or lignite deposits.

Roughly half the Reich's prewar chemical capacity was located in what is now the Western Trizonal area, including three major chemical centers (see *map*). The Rhineland-Westphalian area (now mainly in the British zone) included large plants at Leverkusen, Knapsack, Uerdingen, Troisdorf, Huels, Witten, Duesseldorf, Duisburg, and Gelsenkirchen in the Ruhr. The Frankfurt area (now mainly in the American zone) included important plants at Hoechst, Mainkur, Griesheim, Mainz, Wiesbaden, Hanau, and Darmstadt. The Ludwigshafen-Mannheim area (now in the French zone) included Ludwigshafen, Oppau, and Upper Rhine electrochemical production. Hamburg (British) and Munich (American) also had some specialized consumer-chemical industries.

The other half of the Reich's prewar capacity is located in the present Eastern area. This includes the central German Saxony-Anhalt area with its huge lignite, power, and potash resources. Here was the home of the largest single chemical plant in Germany and the world, Leuna-Merseburg, and the Wolfen, Bitterfeld, Schkopau, Piesteritz, and Eilenburg plants.

In terms of basic chemicals, the East-West separation has divided supplies roughly as follows (see chart on map): In sulphuric acid, 80 percent of the Reich's prewar capacity is located in the West and only 20 percent in the East. Approximate percentages of other capacities located in the East are magnesium 100, phosphorus 100, potash 65, nitrogen 60, aluminum 50, synthetic rubber 50, caustic soda and chlorine 45, soda ash 40.

CAPACITY LIMITATIONS

It will be recalled that the original Berlin Protocol called for prohibiting German production of war gases, primary aluminum, beryllium, vanadium from Thomas slugs, radioactive materials, and concentrated hydrogen peroxide. Output of synthetic gasoline, oil and rubber was to be permitted only until sufficient imports could be obtained. Synthetic ammonia production was to be permitted only until exports could be found to pay for required nitrogen imports. No limitations were placed on output of potash and other chemicals.

Basic chemical output was originally scheduled to be held at 40 percent of 1936 production levels, pharmaceuticals at 80 percent, miscellaneous chemicals at 70 percent.

Since that time the Russians have prevented inspection of plants in their zone, have not applied all the prohibitions previously agreed upon, and in general have gone their own way in reorganizing the industry in their area. They have, among other things, helped themselves to reparation deliveries from current production, which is opposed in principle by the Western powers. As a result, the Western powers have revised their own dismantling schedules and have generally agreed to allow production to reach roughly the 1936 levels in some fields and even exceed them in others. Synthetic ammonia, for example, may be 124 percent of the 1936 output. Dye capacity allowed will be 34,000 tons, just under prewar capacity. After the 1947 London conference it was agreed to allow a 2,271 million mark output, dye exports of 58 million marks (as against 200 to 336 million in prewar years), and pharmaceutical exports of 120 million marks—all figured in terms of 1936 price levels.

CORPORATE REORGANIZATION

Corporate reorganization has also proceeded separately in the Western and Eastern zones, especially since the Soviets left the Four-Power Control Council in the fall of 1947. The biggest corporate change in the industry, of course, has been the reorganization of the vast I. G. Farben holdings, both inside and outside of Germany, to prevent reconstitution of this prewar concern. The extent of its operations may be seen in the pie chart on the next page; it owned or controlled over half the capacity of 20 of the 28 industries shown. The chart is based on figures for 1943, when German chemical capacity was at its highest.

I.G. at that time had stock interests in 613 corporations, including 173 in foreign countries, had total assets of 6 billion RM, and operated with varying degrees of power in more than 2,000 cartels.

In the Western zone, original break-up plans have been changed. Four-power agreement now seems unattainable and it is considered desirable to free the operations from military trusteeship. Reportedly within the next half year 77 chemical enterprises formerly belonging to I.G. Farben and now in the hands of trustees are to be offered for sale to pay off old creditors and stockholders. Sales are to take place at first in the U.S. and British zones, later in the French zone.

In the meantime, the Russians have formed five major Soviet corporations to take over the chief I.G. units in their area. They are not expected to join the Western powers in selling plants to reimburse "capitalist" stockholders and creditors.

Since the Soviet companies produce predominantly for reparation deliveries, their output for the time being really represents a further loss of capacity as far as the East German economy is concerned.

In the Eastern zone capacity losses from dismantling and destruction have ranged from practically no losses in potash, to three-fifths each for sulphuric acid, caustic soda, and nitrogen compounds; fourth-fifths for soda ash, calcium carbide, and carbon bisulphide; nine-tenths for phosphorus;

and complete dismantling in aluminum and magnesium.

WESTERN RECOVERY

The virtual cessation of dismantling in both areas has aided recovery. Both British and French have been disappointed in the net gains as reparations from the dismantling program. Delays, impracticability of moving plants, and a realization that general European recovery might be better aided by allowing the plants to produce in Germany have been responsible for this changed attitude. American "reparations," with a few exceptions, have consisted mainly of information gained on German plants and processes through patents and technical industrial intelligence reports, and the indirect benefits of having a competitor temporarily out of world markets.

It is interesting to note that the German chemical industry is spearheading the propaganda campaign against further dismantling of chemical and other plants. The Coal Chemistry Division of the Wirtschaftsverbund Chemische Industrie is issuing pamphlets protesting further dismantling of at least six Fischer-Tropsch plants in the Ruhr. Their retention, it is argued, would provide synthetic fatty acids and detergents and relieve the need for importing fats, thereby saving scarce foreign currency and relieving American taxpayers of some of the burden of supporting Germany. The propaganda efforts of the chemical industry are reminiscent of similar arguments, especially against occupation, advanced after the last war.

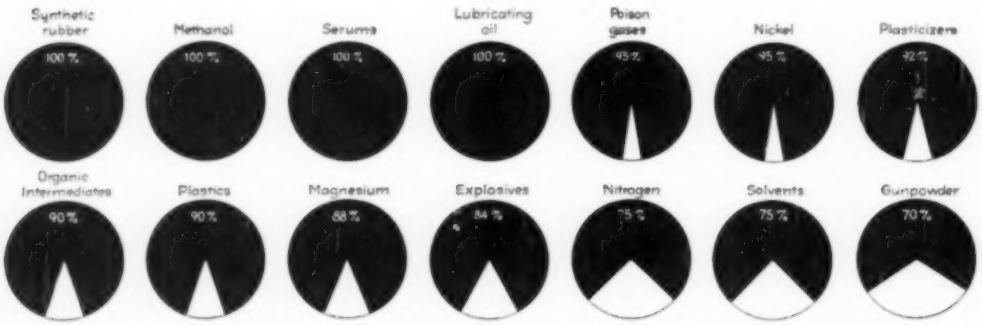
In the Western area the most serious production bottlenecks of the past two years have been shortages of coal, coke-oven gas, steel, equipment, electric power and limestone. Occupation authorities have faced some tough decisions. For instance, should they export more coal directly and obtain needed imports—say give Ruhr coal for Austrian nitrogenous fertilizer? Or should they process the coal in Germany, obtain needed domestic products from it (e.g., fertilizer) and try to get their export credits by selling more refined products, such as dyes, pharmaceuticals and plastics.

Shortages have done more than pose problems. They have shut down plants. Nitrogenous fertilizer plants in the Bizonal area haven't been able to get above 70 percent of capacity. Power shortages were still slowing carbide production in the British zone at the end of 1948. The shortage of ammonia capacity in the British zone was expected to limit ammonia delivery to technical needs. Shortage of glass and paper for packaging—they formerly came from the East—is no help. Sulphuric acid production still depends on imports for two-thirds of its pyrites; domestic production covers only a third. The synthetic fiber industry is beginning to get cellulose again from Scandinavia—but there is not enough sulphuric acid or caustic soda.

Technical journals reflect the same thing. The lack of equipment is apparent in the advertising; many offers are made to swap pieces of equipment, chemicals or raw materials. Chemists and engineers are advertising for work in the West after leaving other areas and plants. From the journals one also gets the impression that the Germans feel they have lost the edge on other countries in research in most chemical fields, with the possible exception of sulphonamide, coal and acetylene chemistry. As a result, concentration in research and production will presumably be in these fields.

But all is not black. In spite of handicaps, production has been increasing steadily. The 1947 output of chemicals was 28 percent higher than 1946. In 1948 the Bizonal area hit half to two-thirds of the 1936 levels. Chemical exports from Bizonia grew to $17 million for the first nine months of 1948. The French had expected to export chemicals worth about $11 million from their zone in the last half of 1948. The Hoechst plant in the American zone is scheduled to increase capacity for nitrogenous fertilizer from 40,000 to 60,000 tons a year by May 1949. The Bayer Leverkusen plant in the British zone now employs 14,000 workers and is busy filling foreign orders for pharmaceuticals, dyes and insecticides.

Such are the symptoms of recovery. What are the reasons for it? Increasing output of Ruhr coal has been good medicine. So has loosening of export controls, especially removal of the rule that German exporters do business only with "hard currency" countries; chemicals figure prominently in the new trade agreements with such countries as the Netherlands, Czechoslovakia, Belgium, Sweden, Italy, Greece and India. The currency reforms of June 1948 have had good effects: enhanced labor efficiency, smoother flow of materials, resurrection of "hidden" stocks of materials. Other factors in the convalescence have been larger imports of vital materials, more and better food, restoration of transportation, and two mild winters. The approval at the end of 1948 for establishing a Reconstruction Loan Corporation to provide medium and long-term credits through the new banking system should also aid recovery and provide capital at lower interest rates. Many domestic and export producers admit they have held secret their new process and product improvements until they were certain the developments could not be used freely by competitors; now they



I.G.'s CUT. It is not news that I.G. Farben was big, but it is interesting to see just how big. The black areas show percent of German capacity owned or controlled by the cartel in 1943, the year when German capacity hit its peak. Not only did I.G. have

have a patent office at Darmstadt (the office expects 50,000 temporary patent and trademark applications in 1949).

The Germans are not forgetting the future. With foreign aid, a 1951 edition of the famous Beilstein's "Handbuch der organischen Chemie" and also a new edition of Gmelin's "Handbuch der anorganischen Chemie" are planned. Universities are continuing technical instruction in spite of losses of library and other facilities. The unique Deutsches Museum in Munich has been restored. The Max Planck Association for the Advancement of Sciences (it replaces the former Kaiser Wilhelm Gesellschaft of Berlin) has recruited 11 Nobel prize winners to establish 34 research institutes in the Western zones.

EASTERN RECOVERY

In the Eastern zone the Soviets have had similar problems and have taken some positive steps in their program of eastward orientation of the chemical industry. In some instances, despite extensive dismantling and reparation deliveries, there has been unused capacity, chiefly because consumers or raw materials have been in the West. Some interzonal trade exchanges occurred until 1947, but this has been generally halted with deteriorated political relations. The lack of basic coal tar products formerly obtained from Western Germany has handicapped part of the Eastern industry. Lignite production, however, has been near prewar levels. Chemical production in 1947, though, was below four-fifths of planned quotas for all products.

The Eastern area also has had to depend on imported pyrites for sulphuric acid production. The only plant, at Wolfen, that made sulphuric acid from gypsum has been dismantled. The Leuna nitrogen capacity is only being partially utilized. Some of Leuna's coal hydrogenating capacity has been switched over to nitrogen. Coal hydrogenation units in general have continued producing in the zone, excepting the German plants in the Polish area which were carted off to Russia; but production has been for reparation, not for East German recovery. Mersol detergent capacity also does not seem to have been greatly disturbed.

The buna capacity of the Schkopau plant was reduced from 60,000 to 20,000 tons by dismantling, but a fairly large carbide capacity was left there. Production of carbide in the Russian zone is now in the magnitude of 200,000 tons a year, about one-third wartime capacity, and suffers from power shortages. The two chief carbide plants, Schkopau and Piesteritz, accounting for about three-fourths of the remaining capacity, belong directly to the Soviet government. Caustic soda plants were extensively dismantled. The five remaining electrolytic plants are producing chiefly for the cellulose industry. They, too, are handicapped by lack of electric power. Needs for other textile chemicals, including carbon bisulphide, are considerably lower than they used to be as a result of the extensive dismantling of chemical consuming synthetic fiber plants.

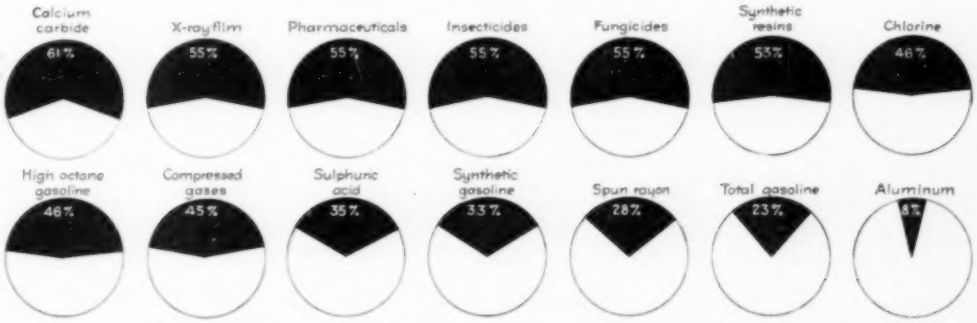
Details of activities in the Soviet zone of Germany are necessarily much sketchier than in the Western zone, but it can be assumed that to a varying degree comparable measures have had somewhat similar effect. In the Eastern zone, like the West, currency reforms took place in 1948, possibly with slightly less effect in view of loss of confidence of the people. And there is a new central banking system, an investment bank and a patent office.

Potash, of which Russia now controls 42 percent of world output, is one of the Eastern zone's greatest assets. Potash production is close to prewar levels. Of the current output of just under a million tons a year, 40 percent is used for agriculture in the Eastern zone, 30 percent for reparation deliveries, and the remaining 30 percent for foreign trade. The Soviets are able, for example, to trade Eastern potash for Dutch superphosphates; and when they add these imports to their own potash and nitrates they are able to meet fertilizer requirements better than the Western zone.

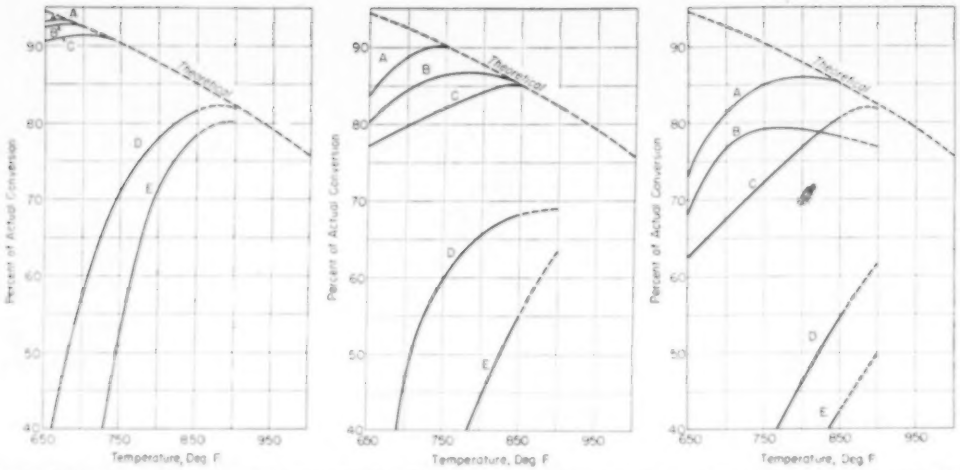
Potash salts and other chemicals will be exchanged for Finnish pyrites in a new trade agreement recently drawn up between the Soviet zone of Germany and Finland.

FUTURE

A review of the German chemical industry's position in early 1949 thus shows that some steps toward recovery have been taken. But as long as Germany does not function as a unit it, chemical industry, like the rest of the German economy, will suffer. The additional postwar handicaps imposed by East-West separation require adjustment of the Western area to European Recovery Program aims, and the Eastern part to Soviet eastward orientation. The loss of markets, raw materials, and difficulties of carrying on foreign trade in view of currency and other political problems are not faced by Germany alone but by the rest of Europe as well. In short, whether or not the German chemical industry regains anything like its former world position will depend to a considerable extent on its scientists, engineers, businessmen, and workers. It depends on their ingenuity, their energy and their willingness to cooperate with each other and with other nations.



its finger in a lot of the juciest pies, but note how often its slice came to more than half. About 55 percent of its properties were located in the Eastern zone of Germany, 45 percent in American, British and French zones.



COMPARISON OF FIVE COMMERCIAL CATALYSTS at three different space velocities (Figs. 1-3, left to right): 400, 800, 1,200 volumes of inlet gas per hr. per volume of catalyst. At all three velocities, "A" shows greatest activity.

What to Look For in CO Conversion Catalysts

Catalysts for the reaction $CO + H_2O = CO_2 + H_2$ vary widely in two important requirements—activity and durability. The way the catalyst is manufactured is as influential as its composition

D. C. CHRISTAIN and PAUL B. BOYD, JR.

Increased consumption of hydrogen has greatly increased the demand for highly active carbon monoxide conversion catalysts since their application results in more efficient production. Data are presented here to show that differences in composition may account for variations in the activities of these catalysts.

Carbon monoxide conversion catalysts, water-gas shift catalysts, shift catalysts, or conversion catalysts, were among the first used in industry. In 1870, Thaddeus Lowe, an American, observed that a gaseous mixture consisting essentially of carbon monoxide and hydrogen was produced by the following reaction when steam passed through a bed of carbon at a high temperature:

$$C + H_2O = CO + H_2$$

It was then observed that if the hot water-gas was passed over certain materials with additional steam a change in composition took place, a part of the carbon monoxide being converted to carbon dioxide with the formation of an equivalent amount of hydrogen according to the water-gas shift reaction:

$$CO + H_2O = CO_2 + H_2$$

The final composition was found to depend on the temperature at which the reaction was carried out and on the proportion of steam employed. In other words, the water-gas shift reaction stopped when a specific ratio of carbon dioxide to carbon monoxide was reached for each temperature and each mixture of steam and water-gas. It was also observed that, for any specific steam to gas ratio, the yield of hydrogen was increased and the carbon monoxide was more completely converted to carbon dioxide when the water-gas shift reaction took place at lower temperatures. (Note slope of "Theoretical" line in charts above.)

The water-gas shift reaction normally requires a very long time to reach equilibrium in the absence of a catalyst. Iron oxide is the most common catalyst used in commercial operations. Today, with the much more active catalysts than formerly, lower temperatures as well as lower steam to gas ratios can be used.

The development and application

Mr. D. C. Christain and Mr. Paul B. Boyd, Jr., are process development engineers in the Gas Processes Division of the Girdler Corp. They are located in Louisville, Ky.

of carbon monoxide conversion catalysts parallel the increased production of hydrogen from sources other than the electrolytic and steam-iron processes. Hydrogen has been produced extensively on a commercial scale for many years by the combined use of the water-gas reaction and the water-gas shift reaction. The subsequent removal of the carbon dioxide is simple and inexpensive and results in the production of relatively pure hydrogen at a reasonably low cost. The sources of carbon are usually high grade coke or charcoal. The hydrogen produced may contain as low as 0.5 percent carbon monoxide and is used without further purification where this amount of impurity presents no problem.

Where hydrogen of a higher purity is required, the gas from the water-gas shift reaction, after condensation of the excess water vapor and removal of the carbon dioxide, can be mixed with additional steam, heated to an elevated temperature and passed over another quantity of carbon monoxide conversion catalyst. This results in conversion of a major portion of the residual carbon monoxide to carbon dioxide with the formation of additional hydrogen. If an even higher purity is required the above procedure can again be repeated after removal of the carbon dioxide. The carbon monoxide can also be removed by absorption in a selective solvent, usually a solution of a copper salt, or it may be hydrogenated to methane by passing the gas over a suitable catalyst. These additional steps would be simplified or made unnecessary if an active catalyst were available which would promote the water-gas shift reaction at a sufficiently low temperature.

NEW HYDROGEN SOURCES

The use of hydrogen in greatly increased quantities has resulted in the development of less expensive sources of hydrogen than electrolytic cells or water-gas generators. The most outstanding development has been the hydrocarbon-steam reforming process in which a light or normally gaseous hydrocarbon or hydrocarbon mixture is catalytically reacted with steam to form a gaseous mixture of hydrogen, carbon monoxide and carbon dioxide. In this process two reactions occur almost simultaneously, the first being the reaction between steam and hydrocarbon to form hydrogen and carbon monoxide, and the second being the water-gas shift which approaches equilibrium under the conditions employed:

$$xH_2O + CxH_{2y} \rightleftharpoons xCO + (x + y)H_2$$

$$CO + H_2O \rightleftharpoons CO_2 + H_2$$

Because of the high temperatures required to promote the first reaction the ratio of carbon monoxide to carbon dioxide in the product gas is high. In order to increase the yield of hydrogen, the gases formed are passed over a water-gas shift catalyst with additional steam at a lower temperature. The carbon dioxide is then removed by some process such as Girbotol or scrubbing the mixture with water under pressure.

SYNTHETIC AMMONIA

At about the same time that the process for producing hydrogen from hydrocarbons began to play an important role in the petroleum industry, an equally important application was made in the field of synthetic ammonia. Within the last six years this method for producing hydrogen has been employed in Hygirtol plants[5] which have made possible the production of low cost commercial hydrogen of a purity equal to or higher than that from any other source.

The increased consumption of hydrogen has greatly increased the demand for highly active carbon monoxide conversion catalysts since their application results in more efficient production of hydrogen. Within the last few years catalysts composed of copper and cobalt oxides[6] have attracted considerable attention but have not been accepted for commercial application because of their high initial cost and relatively short life. Combinations of copper and zinc oxides have been used in certain instances to promote the water-gas shift reaction at elevated pressures in gas streams of low sulphur content. Generally they have not been found satisfactory since they are expensive and are poisoned in a relatively short time by small quantities of sulphur compounds remaining after high-pressure water scrubbing. Iron oxide by itself or in combination with other inorganic materials has been used extensively in commercial operations, because most iron oxide base catalysts are not susceptible to sulphur poisoning.[1] Natural iron ores, roasted sulphide ores and waste oxides, hydroxides and carbonates of iron were used for many years, although all of these catalysts had low activities.

COMMERCIAL CATALYSTS

The iron oxide catalysts used today are far different from those formerly employed both in physical appearance and chemical composition. Compounded catalysts are almost universally used. The best of these catalysts are prepared to formulas from selected chemicals under rigorous controls, and are tableted or extruded in order to better withstand operating conditions. Some properties of five of the principal commercial carbon monoxide conversion catalysts are shown.

These catalysts were all rather similar in composition, except for the large amount of magnesium oxide and corresponding smaller quantity of iron oxide in catalysts *D* and *E*. Even though the compositions of catalysts, *A*, *B*, and *C* are comparable, commercial practice has shown that their performance is different. This has been attributed to the method of manufacture rather than the small difference in composition. Extensive tests to evaluate these five catalysts have been conducted.

The results of the laboratory activity tests on the five commercial catalysts are presented in Fig. 1 to 3. The tests consisted of passing a mixture of hydrogen and carbon monoxide with an equal volume of water vapor over the catalyst at a predetermined temperature and rate. After the catalyst was reduced in size by crushing to 4-8 mesh granules, a 75 cc. sample was placed in a 1 in. I.D. Pyrex tube. Approximately 75 cc. of 6-14 mesh Celite was placed on top of the catalyst to aid in uniformly preheating the gas mixture. The catalyst tube was heated in a vertical electric furnace and the temperature near the bottom of the catalyst bed was measured by means of a thermocouple within a well inserted from the top. The catalyst was reduced before testing by passing a stream of hydrogen, saturated with water vapor at room temperature, through it at the rate of 10-15 liters per hour for approximately 18 hours at a temperature of 650-750 deg. F.

Dry gas mixtures, prepared in cylinders to contain between 20 to 25 mol percent carbon monoxide in hydrogen, were passed through a water saturator, maintained at the temperature required to produce a 1:1 gas-steam mixture, and down through the

Properties of Five Commercial Catalysts

	Catalyst A	B	C	D	E
Iron as % Fe_2O_3	74.2	92.6	90.9	33.0	24.1
Chromium as % Cr_2O_3	10.0	2.4	7.8	1.8	1.8
Magnesium as % MgO	0.2	....	....	56.3	47.1
Volatile below 1,400°F., %	14.0	0.8	1.3	1.7	23.1
Unaccounted for, %	1.6	4.2	1.4	7.2	4.2
Form	Tablets	Tablets	Extruded	Tablets	Tablets
Diameter, inches	3/8	9/16	3/8	3/8	7/16
Length, inches	3/8	5/16	1/2	3/8	5/16
Operating characteristics	Does not dust or spall	Dusts	Spalls	Dusts	Dusts

catalyst bed at the predetermined rate. This particular gas composition was selected so that accurate analytical results could be obtained and also because gases having this approximate composition are processed quite frequently in commercial plants under similar conditions. It has been demonstrated, however, that gases of different composition would indicate the same relative conversions for different catalysts. Representative samples of the product gas were taken from a side stream over a 30-40 minute period and analyzed by the Orsat method. The duration of the tests was 5 hr.

RELATIVE EFFICIENCIES

Fig. 1 shows the relative efficiencies of the five commercial catalysts in the temperature range of 650 deg. to 850 deg. F. at a space velocity of 400 volumes of dry inlet gas, at room temperature and pressure, per hour per apparent volume of catalyst. The line marked "Theoretical" indicates the maximum possible conversion at the various temperatures. This line is extended to 1,000 deg. F. and in addition the experimental curves are extended beyond 850 deg. F. as indicated by the dashed lines, although the experimental data cover only the temperature region from 650 deg. to 850 deg.

Figs. 2 and 3 present data for the five commercial catalysts at space velocities of 800 and 1,200, respectively. In other respects these figures are similar to Fig. 1.

Corrections were made for the temperature variation through the catalyst bed and smoothed curves are shown in Figs. 1 to 3. The characteristics of different reactor systems may vary widely, so that although the data indicate relative efficiencies of the different catalysts they may not give the conversions which would be obtained in commercial operation.

These data show the advantage of selecting a catalyst such as *A* which is active at low temperatures. In a group of catalysts the most active will always give the highest conversion at any given space velocity. For example, 93.8 percent of the carbon monoxide can theoretically be converted to hydrogen and carbon dioxide when a gas containing 25 percent carbon monoxide and 75 percent hydrogen is reacted with an equal volume of water vapor at 670 deg. F. At 880 deg. F. the equilibrium allows for conversion of only 83.5 percent of the carbon monoxide. Fig. 1 shows that the maximum actual conversion of the carbon monoxide at a space velocity of 400 was 93.5 percent, only slightly lower than the theoretical. This conversion was obtained with catalyst *A* at a temperature of 670 deg. F. The maximum actual conversions obtained with the other catalysts were lower than that obtained with catalyst *A* by as much as 13 percent and occurred at temperatures as high as 880 deg. F.

Figs. 2 and 3 show the same trends as Fig. 1, except that as the space velocity is increased the superiority of the more active catalysts becomes more noticeable. In all three of the figures it is apparent that the five catalysts are divided into two groups. Table I shows that *D* and *E*, the two catalysts in the less active group, contain considerably less iron oxide and much more magnesium oxide than the other catalysts. Although the differences between the actual conversions obtained with the more active catalysts, *A*, *B*, and *C*, are not great at a space velocity of 400, they become much greater at higher space velocities.

APPLICATION

The commercial superiority of a low-temperature catalyst such as *A* is illustrated by the following example. In the production of ammonia, using natural gas as a source of hydrogen, where the hydrogen is completely utilized according to the following reaction,

$$N_2 + 3H_2 = 2NH$$

568 cu.ft. of hydrogen per mol of ammonia or 33.4 cu.ft. of hydrogen per pound of ammonia are required. On the basis of a 100-ton-per-day plant, 6,680,000 cu.ft. per day of hydrogen are required. If the space velocity is 400 and if catalyst *D* were selected for conversion of the carbon monoxide, then, since it is necessary to operate at 880 deg. F. in order to obtain the highest efficiency with this catalyst, 82.5 percent of the carbon monoxide will be converted. Then 1,746,000 cu.ft. of methane will be required to produce 100 tons of ammonia, and 308,000 cu.ft. of potential hydrogen will be lost as the result of the failure to convert all of the carbon monoxide. If catalyst *A* were selected for the conversion of the carbon monoxide and since this catalyst operates at maximum efficiency at a temperature of 670 deg. F., about 93.5 percent of the carbon monoxide would be converted to hydrogen, and 1,698,000 cu.ft. of methane would be required. The use of the latter catalyst will save a total of 48,000 cu.ft. of methane or 189,000 cu.ft. of hydrogen per day. The actual gain is equivalent to 2.8 tons of ammonia per day, which is of sufficient value to pay off the catalyst costs for the plant in less than a year. This means that by selecting the proper catalyst and operating at conditions which are most favorable the capacity of the plant can actually be increased 2.8 percent. The selection of the more active catalyst, in addition to increasing the capacity of the plant, decreases the over-all fuel requirements of the process. Among the other advantages of low-temperature operation is the reduced cost of removing the smaller quantity of carbon monoxide.

According to the example given above a more active catalyst will always be preferable to a less active one. However, in the selection of the proper catalyst for use in a particular application several factors other than activity must be considered.

The size of catalyst particles must be such that the allowable pressure drop across the catalyst bed will not be exceeded under operating conditions. Carbon monoxide conversion catalysts are usually available in a standard size which is suitable for most applications, but other sizes may be prepared if they are required.

Since the value of the lost production resulting from changing a catalyst may frequently approach its initial cost, prospective life is a much more important factor in catalyst selection than is the original cost. Some catalysts when subjected to relatively high space velocities are partially reduced to a dust which accumulates in the catalyst bed. Channeling of the gas flow, increased pressure drop and unsatisfactory conversion of the carbon monoxide have resulted from the dusting, and eventually the operation has had to be interrupted and the catalyst either removed and screened, or discarded and replaced with new catalyst. Catalysts *B*, *D*, and *E* are subject to serious dusting. Other catalysts, although they do not dust, must be removed and screened at intervals because they spall under the conditions used in carbon monoxide conversion. Since catalyst *C* spalls, catalyst *A* is not only the most active but is the most rugged catalyst of the five studied.

It is evident from data presented in this paper that large differences in composition may account for variations in the activities of carbon monoxide conversion catalysts. However, the method of manufacture also has a large influence on the activity of a catalyst, and is the major factor in determining the physical properties.

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Economics of Plant Expansion

There is far more to chemical plant expansion than the development of a new product. Here are some of the salient economic factors to be considered

BLYTHE M. REYNOLDS

It is a frequent complaint of technical men in the chemical industry that management fails to exploit, or delays unduly in exploiting, the opportunities for expansion that they believe they have created for the company. Such complaints call for a better understanding, by technical men, of the economics involved in chemical plant expansion. Here are my ideas on the subject.

To proceed with expansion programs management must be satisfied that the investment is justified. This should be done only after a complete and accurate study of conditions concerning labor, raw materials, prospective markets, competitive processes, cost, etc. has been conducted and evaluated. In addition to this, capital for the project must be available. You can't squeeze blood from a turnip, even to exploit a new product.

In considering what constitutes a justifiable investment in manufacturing plants the products to be made may, in general, be classified into two types. They are either staple products in competition with products of other manufacturers or they are new products not directly competitive. The basis for justification of one differs markedly from the other.

In the case of staple products where the product from a new plant must compete with products produced in older plants the present high cost of construction becomes a heavy penalty on current expansion. In general, present construction costs are more than double those of eight years ago. This means that depreciation and amortization charges as a part of the cost of production are much higher on the product from a new plant.

The problem of high construction costs has become so acute that some of the leading chemical manufacturers have recently announced that they would build no more plants to produce staple products under present conditions except in very unusual circumstances.

On the other hand, construction of new plants is proceeding and should proceed where the justification is adequate, and the resourcefulness of American industry is again demonstrated in the new and cheaper methods of construction used. Chemical operations are being put outdoors wherever possible. Single, rather than multi-story buildings are being built, not only to save initial investment but to effect operating economics.

With staple products, the market prospects must be very promising not only as to the present, but the long-range demand. For the past three years the export market requirements have been excessive, and the cause of many shortages. The future prospects of this market are so uncertain for most products that expansion to meet this demand cannot be justified. In gauging the effect of the export market on current demand, it is essential to include all indirect sales for export: i.e., domestic sales for use in products which ultimately are exported.

In expanding the production of staple products advantages to be gained by reduction in manufacturing costs, due to large volume and process improvements, are frequently the primary justification. This is a valid justification provided you are sure the volume will be sustained and that the process improvements are dependable.

Where the probable market is such that the new production has to be sold in competition, new production should be 20 percent cheaper than that of competition.

Production of a staple product may be justified on the basis that it will provide raw materials heretofore purchased or provide an outlet for raw materials manufactured and thereby greatly improve the fundamental soundness and independence of the company in its vertical integration from basic raw materials to consumer.

Expansion of this type may represent an overextension unless low cost capital is available and the new production is much cheaper than competition.

Probably the best example of the difficult problems involved in justifying expansion of a staple product today is represented by the steel industry. The President said that further capacity is required and if necessary, the government will take steps to finance it. Industry has stated its case as follows:

FIVE OF THE FOREMOST ECONOMIC FACTORS CONDITIONING CHEMICAL PLANT EXPANSION

1. The total capital required for expansion is normally double the fixed plant investment, to provide for inventories and other working capital needed.

2. Amortizing a new plant at today's high construction costs may boost the cost of producing the product above that of competitive products made in plants built at low prewar prices.

3. While new non-competitive products are not so much affected by high construction costs, the risk is greater since the market is unproved. Timing should be right and profits before taxes are removed should be approximately ½ of the total fixed capital requirement of expansion.

4. Venture capital is discouraged by government taxes and controls. While corporation earnings are at new highs, dividends, reserves, and expanding inventory requirements leave insufficient funds from earnings to provide desired expansion.

5. In spending one dollar for research, management commits itself to spend considerably more on fixed charges before production returns will justify that research. When research developments cannot be translated reasonably promptly into production units, a company has exceeded the amount it should be spending for research.

Blythe M. Reynolds was elected vice-president of Merck & Co., Inc., in charge of engineering and purchases on Oct. 27, 1948. A graduate of Clarkson Coll. of Tech., B. S. in Ch. E., 1916 and M. I. T., where he received his M. S. in 1920, Reynolds has been prominent in the chemical field for years, serving as president of his own Reynolds Chemical Co. from 1926 to 1930. He was vice president of Heyden Chemical Corp. prior to joining Merck & Co. as director of engineering in 1944. *This paper was presented at a regional meeting of AIChE in Columbus, Ohio, March 18, 1949.*

(1) production today at 96 million tons is more than double the prewar average. Production has been expanded about 8 percent since the war. (2) The present demand is abnormal, due in part to low foreign production and in part to accumulated civilian demands delayed by the war. They estimate supply and demand will be in balance within one to one and a half years. (3) Were steel production expanded another 10 percent as the government suggests, three billion dollars would be required. Three million tons of finished steel would be needed and the new plants could not be activated for two and possibly three years. (4) Any expansion of steel production would have to be integrated with additional supplies of scrap iron and iron ore. In essence the steel industry does not believe expansion is warranted because in their opinion supply and demand will be in balance before additional capacity could get into production and the present high cost period is not the time to build steel mills.

NEW PRODUCTS

Expansion in products which are new is normally more hazardous because of an unproved market. The anticipated return on the investment should, therefore, be greater to offset the greater risk. Many chemical companies accept the rule that today a new product should indicate a yearly profit before taxes of approximately a third of the total fixed capital requirements. The risk of obsolescence and process and product changes must be taken into consideration. A new product must show satisfactory market outlets exclusive of export and should improve the company's position either through vertical integration or a broadening of its base through diversification.

The timing of production on a new product is always of first importance. Early production meets the most urgent market demand when the profits are best and also permits development of operating economies before competition is established. The timing problem for management is in determining when the process is sufficiently developed to avoid costly plant alterations and also when the market indications are sufficiently reliable to risk capital.

It is here that the ingenuity displayed by some companies in the use of miniature pilot plants pays big dividends. Valuable time is saved in translating laboratory results into factory production when it is not necessary to assemble a large scale pilot plant and to suffer the lag incident to its operation.

Now we turn to the sources and factors controlling the availability of capital. The present time is a rather difficult one for raising venture capital. Fundamentally, this is due to our tax system with the high corporation taxes and double taxation on earnings, once to the company and again to the stockholders. These problems become more acute with the threat of higher corporation taxes and the control of earnings by the 1949 Congress.

AVAILABILITY OF CAPITAL

The sources of new capital are listed below in the order in which they normally occur in meeting expansion requirements. The first is from earnings in excess of dividend payments. It would appear that in a high earning period such as the present, this source would take care of expansion requirements. With the rapid growth of the chemical industry, this is not the case. To preserve a company's financial standing and to satisfy the stockholders, it is necessary to pay adequate dividends. In the case of privately controlled corporations, the government makes this practically mandatory through Section 102, which states that if the company fails to pay reasonable dividends, with the intent of cutting individual surtaxes, the undistributed profits are subject to a further tax.

In addition to dividend requirements, a large percentage of earnings must be used for increased inventories and working capital, as a result of expanded sales. The net result is that now with rapidly growing chemical companies excess earnings do not provide sufficient capital for expansion requirements.

In former years some funds for expansion were taken from depreciation reserves. The Bureau of Internal Revenue normally permits buildings to be depreciated at 2½ percent per year and process equipment in varying amounts up to 10 to 12 percent. The average for all fixed assets is usually approximately 6 percent; however, with replacement costs much higher than original costs, depreciation reserves today are usually inadequate for necessary normal replacements.

A third source of money is from common stock. This represents the greatest risk type of investment in the business and through voting power governs control of the business. With the current low ratio of stock prices to earnings, management is loath to use this means of raising money.

The fourth method of raising new money is through preferred stock with or without convertible features. Several years ago, well rated companies could raise money by this means with dividend rates of 3 to 3¼%. The fact that these preferred stocks are now selling at discounts of 10 to 20 percent shows that prices are now increasing. Nevertheless, preferred stocks represent one of the most popular means of raising money.

Debt financing, the alternate for equity capital, has the drawback that it is not only a fixed obligation as to principal and interest, but must be paid off on a definite maturity date. It is obvious that an obligation of this type is less to be desired by a growing chemical industry. Debt financing has the advantage that interest payments are deductible for tax purposes while payments to equity capital are not.

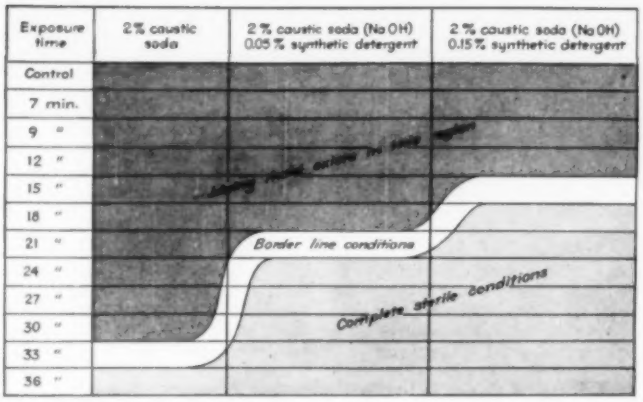
The cost of capital is an important factor in any plans for expansion. Prevailing interest rates and general market conditions govern capital cost to a large extent. This is another way of saying that the confidence of investors controls the cost of new capital.

A normal inventory turnover in the chemical industry is three to five times per year. If the turnover is four times per year, then the inventory will be 25 percent of the yearly sales. With annual sales volume normally at least double the new plant cost, this means that capital for inventory adds 50 percent to the fixed capital investment. Utilities and services such as laboratories, shops, packaging and shipping facilities, and office may on the average add another 50 percent, so that the total capital requirements probably average double the cost of the production unit. This is frequently lost sight of because the utility and service expansion is not usually concurrent.

The relation of research expense to capital requirements is an intriguing problem. While there is considerable variation between the different types of chemical manufacture in the percentage of sales which can justifiably be spent for research, the chemical industry as a whole averages about 2 percent of its sales dollar for research.

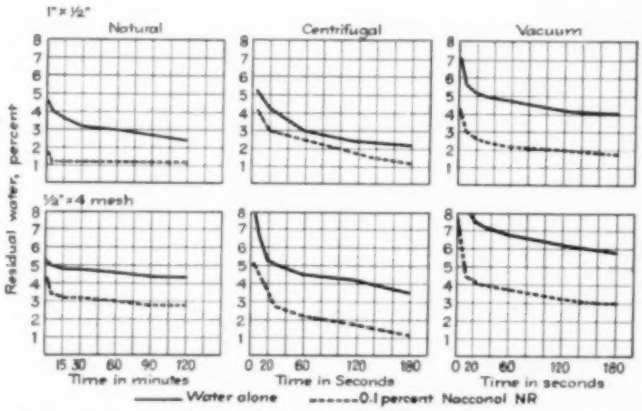
While the ratio of capital required to the money spent for research varies considerably, it is generally in excess of $2 in capital requirements for every $1 spent on research work. This capital includes not only that for buildings and process equipment, but also that to provide utilities, services and inventories.

When a company reaches a point where it cannot, within a reasonable time, provide plants to produce the new products which its research has developed, then it has reached a point of diminishing return in its research program.



CLEANING EQUIPMENT. Wetting action is only one of detergent's assets. Fungicidal action also shows up in this test on the mold penicilium glaucum.

CHANGE PROPERTIES OF OTHER MATERIALS. For instance this concrete highway stands freeze-and-thaw better because it contains a detergent.



ACCELERATE PROCESSES. Charts show, for example, that coal drains drier, quicker if wash water contains just a little nacconal detergent.

Three Ways To Use Synthetic Detergents

As tools of chemical engineering they may have more possibilities than you realize

O. M. MORGAN

A chemical engineer uses many tools. The synthetic detergent is a new one which offers many advantages. The first versatile and inexpensive synthetic detergents were developed from petroleum by the National Aniline Division, Allied Chemical and Dye Corp. These products are distributed under the trademark Nacconol. They possess a combination of physical and chemical properties which allow them to be used under practically any operating condition with which a chemical engineer will come in contact. These organic detergents are stable to acids and alkalis, and to alkaline earth salts such as are found in hard water. They will perform their wetting, cleansing, emulsifying and other functions in all types of solutions. They will withstand reasonable attack by oxidizing and reducing agents. In their dry form they are not adversely affected by extended baking up to temperatures of 350 deg. F. Their surface active characteristics allow them to promote spreading and penetration of aqueous solutions. This, combined with their emulsifying

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and dispersing ability, accounts for their excellent cleansing properties.

The uses of Nacconols which are of particular interest to chemical engineers as a group may be divided into three general classes. These include: (1) cleaning, (2) changing physical characteristics of other materials, (3) acceleration of processes.

Almost every production problem has a cleaning problem associated with it. The cleaning problem may precede or follow the process or it may be an integral part of the process itself. It may involve the cleaning of tank cars or tank ships prior to shipment of a finished product. Many of these cleaning jobs are considered as a necessary nuisance and in some instances the tendency is to slight them, with undesirable consequences.

INTERNAL CLEANING

The chemical engineer is faced with two general types of cleaning operations. One of these is the internal cleaning of equipment which provides difficult access; the other is external cleaning, much easier to accomplish.

When designing equipment, a good deal of thought should be given to the selection of construction materials which will allow for their internal cleaning without dismantling. This would include the elimination of any unnecessary pockets or recessed areas which are difficult to clean by virtue of their physical shape and the ease with which they may be reached by cleaning solutions. The dismantling of equipment for cleaning purposes is time consuming and expensive and if this can be avoided, it is a job well done. The great majority of these internal cleaning jobs may be accomplished with a chemically stable synthetic detergent either by itself or in the presence of a suitable alkali or acid.

In the cleaning of heat exchangers suitable detergent solutions may be pumped through the system until all foreign matter has been removed. A coating of lime scale or oil will greatly reduce efficiency. If there is a problem of removing lime scale, this may be done with a suitably inhibited 2-5 percent solution of muriatic acid containing 0.20-0.50 percent Nacconol NR at 80-100 deg. F. The presence of the synthetic detergent allows for more rapid and more intimate contact of the acid solution with the lime scale and thereby achieves its more rapid removal. Acid will be consumed during this operation and replenishments may be necessary. This acid wash is usually followed by an alkaline rinse containing a small amount of the detergent to assure the complete removal of the acidic cleaner.

Built up coatings of oil or grease may be removed by pumping a 2-5 percent solution of a suitable alkali, such as trisodium phosphate or sodium metasilicate, containing 0.25-0.50 percent synthetic detergent through the system for 30 minutes to 2 hours at a temperature sufficiently higher than the softening or melting point of the oil or grease to facilitate its easy removal. To complete this operation the system is rinsed with water.

The cleaning of distillation columns is a time-consuming task should it be necessary to dismantle the column. By simple preliminary experiments the chemical engineer should determine if the material to be removed from the column is susceptible to treatment by acid, neutral or alkaline synthetic detergent solutions. He should also determine whether the cleaning process is facilitated by heat. With this preliminary information he is then in a position to design his own cleaning solution. Solutions similar to those described for the cleaning of heat exchangers may be suitable. Arrangements can then be made to provide a pump by means of which the cleaning solution can be circulated. The pump should be protected by a filter on its suction side. The cleaning solution may be prepared in the distillation vessel or in an outside tank and circulated through the pump to full cone sprays or a manifold spray located at the top of the column. For certain types of work this spray head may be built as an integral part of the column so that it will be there, ready for use whenever a cleaning job is required. The process is completed by rinsing with water or an alkaline solution followed by water if acid has been used.

Internal cleaning of condenser tubes may be accomplished with the same types of cleaning solutions as used for distillation columns. In many cases vertical condenser tubes may be cleaned by spraying the cleaning solution into them. Sloping condenser tubes should be filled with the cleaning solution which is circulated through the tubes until cleaning has been accomplished. This is followed by a suitable rinsing operation.

Vacuum evaporators for milk, fruit juices, etc., must be cleaned frequently and much time can be saved by using the newer cleaning methods. Where the material to be removed is of a protein type an alkaline cleaner containing Nacconol NR similar to those described above may be used with success. Where appreciable quantities of lime are to be removed the acid treatment described for heat exchangers may be applied. Slowly water soluble materials can generally be removed with a neutral cleaning solution containing 0.25-0.50 percent detergent. Heat usually accelerates this cleaning process. Temperatures of 140-160 deg. F. may be used.

Large tanks generally do not present easy access for cleaning purposes. By preparing an acid, neutral or alkaline cleaning solution containing a synthetic detergent and applying this under pressure from a hose an excellent cleaning job can be done. The solution may be prepared in the tank itself and then by circulating this solution through a pump and special types of nozzles good distribution can be obtained to any part of the tank. Special nozzles are available for this purpose. These can be manipulated from the outside in any direction and thereby reach all of the tank surfaces. Whirling nozzles actuated by the stream pressure are also suitable for this type of work.

EXTERNAL CLEANING

There is a wide variety of external cleaning problems. The exteriors and interiors of buildings in chemical plants become soiled rather rapidly by air borne dirt. The amount of labor involved in the cleaning of painted buildings is greatly reduced by using a small amount of synthetic detergent along with the alkali normally used for this purpose. For the cleaning of brick or stone buildings a small amount of Nacconol NR is added to the cleaning acid. A neutral cleaner of this type does not attack the paint on floors and walls. A wet floor that has just been washed with a synthetic detergent exhibits a greatly reduced slipping hazard as compared with that of a soap or alkali cleaner and is much safer. The neutral synthetic detergent has definitely established its value for this purpose.

Synthetic detergents are playing an increasingly important part in all of these cleanliness programs. A greasy machine can be cleaned up by scrubbing it with 0.2-0.5 percent synthetic detergent solution either neutral or containing a small amount of mild alkali. Where painted machine surfaces are to be cleaned it is best to use a neutral cleaner wherever possible to avoid damage to the paint. The synthetic detergents are ideally suited to this job.

Many plants possess large cooling towers out doors which become contaminated with fungus growths, particularly in the summer months. It is a major job to clean one of these water towers, many hours of labor being required. In most instances the water passing through these towers or a large proportion of it is recirculated.

By adding 1 lb. of synthetic detergent per 1,000 gal. of water, it is possible to gradually effect removal of fungus growths. Circulation of this solution for a week is usually adequate to clean the cooling tower of mold growths.

CHANGES IN PHYSICAL PROPERTIES

A chemical engineer is well aware of the change that may be effected in the physical properties of many products by the use of small quantities of suitable addition agents. There is an ever increasing list of items where a synthetic detergent is playing an important part as an addition agent.

Advantage is taken of the property of a wetting agent in the manufacture of bibulous papers such as blotting paper and paper towels. A dilute solution of the wetting agent is sprayed onto the paper during its final drying operation. This not only increases the amount of water which the paper will hold, but also increases its rate of pick up of the water. Hold a piece of this type of paper between you and the light and atomize some water onto it. If a multitude of bright spots appear in the paper immediately, you will know that it has been treated with a wetting agent.

The foaming ability of the synthetic detergent combined with its lime resistance allows it to be used as an air entraining agent in portland cement, plasterboard, dentifrices, etc.

Experimental concrete highways containing Nacconol NR have shown that by entraining about 5 percent of air in concrete its resistance to numerous cycles of freezing and thawing is increased tremendously. This is explained by the reduction of the thermal coefficient of expansion of the concrete. When the concrete does not expand or contract excessively with changing temperature its tendency to scale at the surface is essentially eliminated.

The amount of detergent which is used to achieve this result in concrete is very small. The recommended concentration is 0.01-0.02 percent based on the weight of the dry portland cement. This may be interground with the cement at the mill during manufacture or it may be added at the mixer by the contractor on the job.

Several benefits are derived when synthetic detergent is used as an air entraining agent in plasterboard. In the first place the board is stronger and lighter in weight and shipping costs are thereby reduced. In the presence of such a wetting agent lesser quantities of water are required to make a workable plaster mix. This means that less water must be evaporated in the kilns and production rates can be increased. Here the savings in fuel in the operation of the kiln are more than enough to pay for the amount of detergent used.

Rare is the chemical plant that does not have some wet processing operation that could be improved by a dash of the proper synthetic detergent.

ACCELERATION OF PROCESSES

The ability of the synthetic detergents to reduce the surface tension of aqueous systems and thereby improve the wetting and penetrating properties of water as well as certain organic liquids such as glycerine or ethylene glycol has provided means of accelerating many otherwise slow processes. It is now fairly well recognized that water is only a second class wetting agent when used by itself. The textile industry was probably the first to recognize this salient fact. Many other industries are now taking advantage of accelerated wetting to speed up their processes.

Accelerated drainage of water from coal is being achieved by the proper application of synthetic detergents. Here again the ability of the detergent to reduce the surface tension of water plays an important part. Water droplets can no longer exist since they flatten out and drain away. A large percentage of bituminous coal and practically all anthracite coal is wet processed. The coal is wet as it leaves the preparation plant and in the winter time freezing hazards are encountered if adequate drainage has not been obtained. In addition to this the coal company must pay freight charges on the water as well as on the coal. It is not difficult to justify the use of a synthetic detergent on this basis. Similar improvements in dewatering action are obtained through the use of the detergent under conditions of natural gravity drainage as associated with shaker screens and in vacuum drainage such as would be obtained on rotary vacuum filters.

Most chemical engineers, at one time or another, have encountered a very difficult slime filtration problem. Filters are plugged up and production stops. Many, but not all, slime filtrations may be accelerated by the incorporation of a small amount of this synthetic detergent in the mass to be filtered. Batch filtrations that normally required about eight hours have been brought to completion in a half hour through the use of this wetting agent.

Tobacco for cigarettes is impregnated with humectants such as glycerine or ethylene glycol. Following the application of the humectants the tobacco is held in bins for a period long enough to allow the humectant solution to thoroughly soak into the leaf. Soaking times may be reduced 25-50 percent through the addition of a small amount of Nacconol to the humectant solution.

Synthetic detergents are used for the removal of oil from metal surfaces prior to electroplating, painting and enamelling. Although it may be used by itself for some of these proposes, it is generally more economical to use it in conjunction with either alkalis or acids.

By using a synthetic organic detergent in conjunction with an alkaline cleaner it is possible to operate at lower alkali concentrations and to obtain satisfactory cleaning results over a wider temperature range and in a shorter period of time.

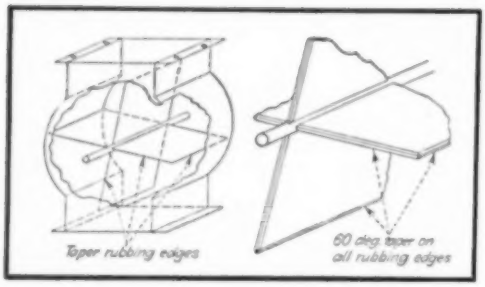
Wetter water for fire fighting comes as a result of using wetting agent solutions. This application has received a great deal of publicity in the last few years and most fire companies retain a supply of a suitable wetting agent for use in the handling of fires in materials which are difficult to wet. This includes overstuffed furniture, mattresses, hay, straw, grain, bales of cotton, piles of coal and similar materials.

IN A WORD

During the present discussion we have shown that this new synthetic detergent tool has speeded up internal and external cleaning operations, has served to provide desirable changes in the physical characteristics of certain products and has aided in accelerating quite a variety of physical and chemical processes. The chemical engineer can profitably ask himself, "Do I have any wet processing operations where a suitable type of synthetic detergent will be of assistance?" The answer will invariably be in the affirmative.

The Plant Notebook

THEODORE R. OLIVE, *Associate Editor*



How to Reduce Friction Loss in Rotary Feeding Devices

ROBERT L. MILLER, *Plant Engineer, Kamen Soap Products Co., Barberton, Ohio.*

★ **March Contest Prize Winner**

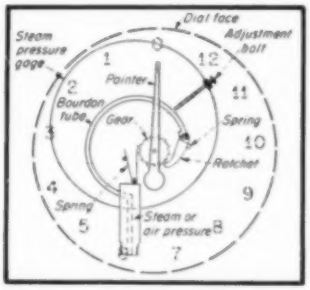
In handling powders or other materials which are "sticky" and tend to pack, the chemical engineer often has trouble with feeding devices which tend to drag or freeze. This means heavy power consumption for the feeder and it may mean frequent cleaning or high maintenance. A few examples will make the problem clear.

One case is the use of a star feeder or rotary air lock in removing a powder consisting of soda ash containing calcium chloride, and perhaps 10 percent moisture, from a dust collector following a spray dryer. It is not uncommon in such a case to find a 3- to 5-hp. geared motor driving the rotary air lock, in spite of the fact that the theoretical horsepower in some designs is less than zero. Another case is the conveying of a material such as clay from a pug mill by means of a screw conveyor. If such a unit is to operate over a period of time the operator had better be prepared for flushing or quick dismantling of the conveyor.

These and many other cases seem to operate as they do because the following conditions exist: (1) All of these devices have a greater or lesser clearance between a moving element and a surrounding case. (2) Since there is always some dead space between these elements, the powder tends to build up and densify in the space. (3) This cake tends to pack harder and harder until either an equilibrium is reached, or the equipment is cleaned. It is clear that such an equilibrium can occur, since, with heavy enough construction and enough power input, equipment of this type can be kept in operation day after day.

It happens that there is a simple solution to the heavy friction loss that occurs. This loss is the product of the friction factor, the area of moving part exposed to the rubbing surface, and a force which is normal to the force of friction. There is usually nothing we can do about either the friction factor or the normal force, but we can reduce the friction loss in direct proportion as we reduce the surface of contact. This means simply that we must sharpen the rubbing edge of the moving element.

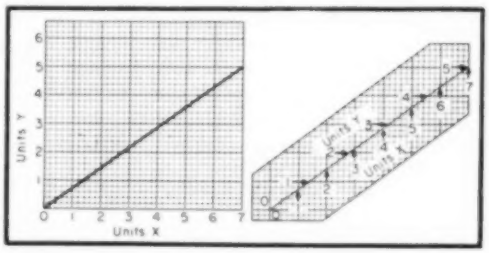
In various heavy chemical and soap industry situations I have found several dozen applications for this simple scheme. It has its limitations, but can be extremely helpful if applied with judgment. The best method seems to be to grind the contacting edges to a 60-deg. bevel. They need not be turned forward as a scraper. They must of course be kept sharp by hardening or occasional regrinding, but work effectively as long as the contact edge is small in area and is kept normal to the built-up surface.



Cycle Counter Made From Gage

JOHN LEHNUS, *Minneapolis, Minn.*

Sometimes it is desirable to record the number of operating cycles through which some piece of batch equipment has gone. If a part of the equipment operates under steam or air pressure when the equipment is working, but this pressure is shut down between cycles, the scheme shown in the sketch will fill the bill. I made the counter from a discarded pressure gage. Its construction is clear and it will be evident that the pointer will advance one unit each time the pressure is turned on. Obviously, the pressure must be released to bring the ratchet back, ready for the next cycle. The number of teeth on the ratchet gear determines the number of units on the dial.



Better Conversion Charts Are Easy to Make

BRYCE I. MACDONALD, JR., *Chemical Engineer, General Electric Co., North Troy, N. Y.*

Chemical engineers, chemists and process operators are constantly called on to convert numerical information from

one set of units to another. Where many readings are to be taken, for example in flow meter calibration, it is usual to make a conversion chart or graph for this purpose.

It seems to me that force of habit causes the great preponderance of such charts to be prepared in the classical way as indicated in the left-hand chart above. Although such a chart may be a thing of beauty, it is not necessarily a joy forever—for it is difficult to read and often is read erroneously. The eye must travel relatively long distances in using it, and it is easy to become confused in following the proper line among the mass of lines on ordinary graph paper.

The scheme shown at the right of the diagram above obviates this difficulty. It is a great timesaver and, what's more, it is almost foolproof.

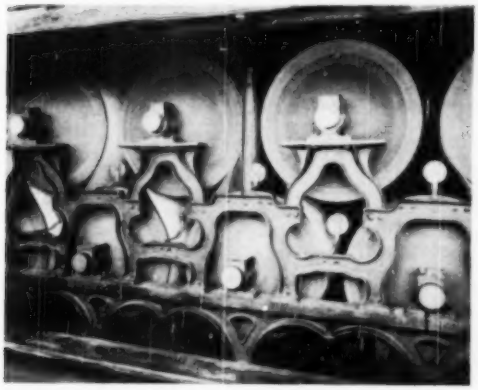
Quick Conversion From Metric to English System

H. RICHARDSON, *Research Corp., Bound Brook, N. J.*

An apparently unrecognized relation makes it easy to convert gas calculations involving the molal volume from the metric to the English system. Thus the normally tedious conversion required in transposing the results of the laboratory to pilot plant operation can be very easily side-stepped, simply by a substitution of nomenclature. Here is the trick:

1 gram mol = 22.418 liters
1 ounce mol = 22.438 liters

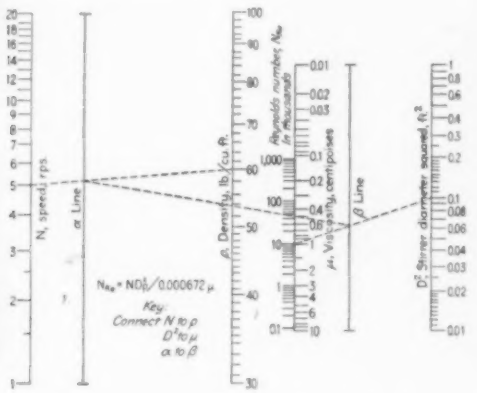
both being the molal volume at 1 atm. and 32 deg. F. Thus the error in substituting ounce mol for gram mol is only about one-tenth of 1 percent.



Upping Board Machine Capacity

Production capacity on its 50-year-old paper board machine has recently been increased by 10 percent at the Riegelsville, Pa., mill of Durham Paper Board Co. This was accomplished by installing tubular warm air outlets between the steam heated drums of the dryer. The dryer has 35 drums supplied with 40-lb. steam. Between the pairs of drums 18 5-in. perforated tubes were installed, supplied through 8-in. risers from a main duct of 30 in. tapering to 20 in.

Air is heated to 175 deg. F. by a 1,500,000 Btu. per hr. Dravo Counterflo heater burning No. 5 fuel oil. The air inlet to the heater, supplied through a booster fan, admits either all outside air, as in summer, or part recirculated air, as in winter. Heater efficiency is said to be 80-85 percent.



Reynolds Number Chart for Agitation Studies

ROBERT W. SCHNEIDER, *Chemical Engineer, Lehigh University, Bethlehem, Pa.*

In agitation studies one often needs a Reynolds number for predicting the performance of the agitator. The chart presented here aids the calculation of the Reynolds number and eliminates the chance of errors in the decimal point.

Use of the chart is easy. First connect the agitator speed N, in revolutions per sec., with the solution density ρ in lb. per cu. ft., marking where the line crosses the tie line α. Then connect the viscosity of the solution μ, in centipoises, with the square of the stirrer diameter in ft.,

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. . . for an article describing how to plug a bottom outlet in a liquid storage tank, for emergency repairs to the outlet line when the tank cannot be emptied, which has been judged the winner of our April contest. This article will appear in our June issue.

$50 PRIZE FOR A GOOD IDEA—Until further notice the Editors of *Chemical Engineering* will award $50 cash each month to the author of the best short article received that month and accepted for publication in the Plant Notebook.

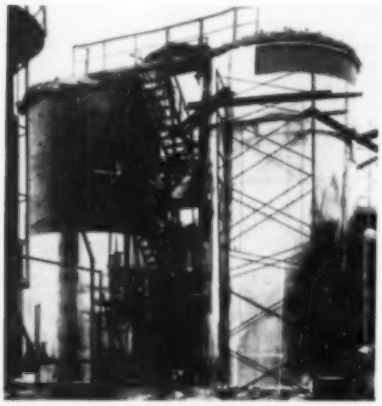
The winner each month will be announced in the issue of the next month, e.g., the May winner will be announced in June and his article published in July. Judges will be the Editors of *Chemical Engineering*. Non-winning articles submitted for this contest will be published if acceptable at our usual space rates.

HOW TO ENTER CONTEST—Any reader of *Chemical Engineering*, other than a McGraw-Hill employee, may submit as many entries for this contest as he wishes. Acceptable material must be previously unpublished and should be short, preferably not over 300 words, but illustrated if possible. Articles may deal with any sort of plant or production "kink" or short-cut that will be of interest to chemical engineers or others in the process industries.

Also, novel means of presenting useful data, as well as new cost-cutting ideas, are acceptable. Address Plant Notebook Editor, *Chemical Engineering*, 330 West 42nd St., New York 18, N. Y.

D'. The intersection of this line with tie line β is also marked. A line joining the two intersections on the α and β lines intersects the Reynolds number axis at the desired N_{Re}.

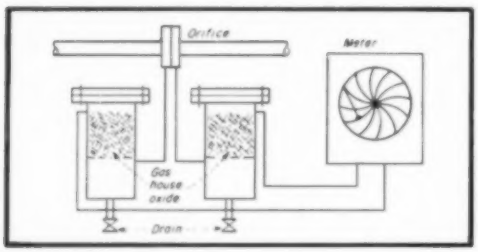
For the example shown a liquid of $\mu = 1$ cp. and $\rho = 60$ lb. per cu. ft. is agitated by a stirrer of 3.8 in. diameter, turning at 5 rps. Connect $(3.8/12)^x$ with $\mu = 1.0$. Connect $N = 5$ with $\rho = 60$. Join the intersections of these lines on the α and β lines, intersecting the Reynolds number axis at $N_{Re} = 45{,}000$.



Aluminum Jacket Holds Loose Insulation on Tank

Two large storage tanks in a Montreal refinery were recently insulated successfully with a 3-in. thickness of loose mineral wool by the use of an aluminum jacket. The aluminum sheets were attached to the tank surfaces with "Z" lugs and the mineral wool was packed into the intervening space at each rise of the sheets.

By installing the insulation at proper density the refinery anticipated no settling. The aluminum sheets not only supported the insulation but also served as a weatherproof protection and vapor seal, making the usual weatherproof coating unnecessary.



Protecting Instruments Used on Sulphur Bearing Gases

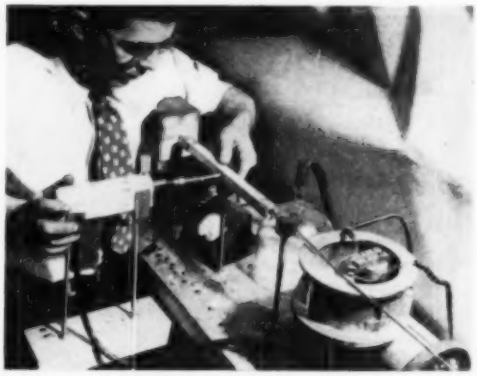
WILLIAM C. SOUDRIETTE, *Chemical Engineer, Gary, Ind.*

The average refinery or chemical plant uses control or recording instruments on gas streams containing sulphur compounds. When in this service the meters require frequent maintenance as a result of the corrosive nature of the material.

This difficulty may be overcome by installing filters on the two lead lines from the orifice plate to the instrument. These filters have a packing composed of iron oxide on wood shavings. This may be purchased from a company manufacturing spongy iron oxide for gas plant use, or can be made by rusting iron borings.

The filter chamber is constructed according to the service required. For low pressures a section of 6-in. pipe with screwed caps may be used, while for higher pressures a flange may be welded to the pipe and this closed with a blind flange.

Packing material is supported on a screen above the inlet so as to allow space for any liquid to accumulate and be drained. The packing lasts for a period of months as flow does not occur; only a static pressure change in the lead lines.



Testing 13 Miles of Tubing for Submicroscopic Leaks

In one of its research projects the General Electric Co. recently had need for 13 miles of ¼-in. O.D. copper tubing which would be completely free from leaks. It was to be used as a water-cooled conductor in a vacuum chamber. The tubing came in 100-ft. lengths which were then induction-brazed into mile-long lengths. This looked liked a job for one of the company's leak detectors.

As worked out by John S. Hickey, research laboratory engineer, the method was as follows: Each mile-long length was filled with a mixture of eight parts of nitrogen and one part of Freon until the gas escaping at the far end showed Freon as indicated by the leak detector. A valve on the tubing end was then closed and the pressure built up to 600 psi. Except for about 5 ft. at each end of the coils, which were tested by hand, the actual leak test was conducted by running the tubing through a special pick-up as shown in the illustration. The rate was about 1 fps., using a motor-driven winding drum and a simple friction brake on the supply drum.

The 13 miles of tubing had about 675 joints, seven of which showed leaks on the test. There were also two porous sections and three "folds" evidently due to ingot flaws which closed on drawing the tubing. As a final check each reel, fully charged with gas, was put in a cardboard box for a week and tested for Freon. One reel which showed a leak was re-run on the test bench and a bad joint found which may have cracked when the reel was wound after the first test.

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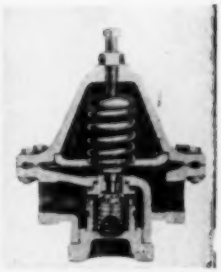
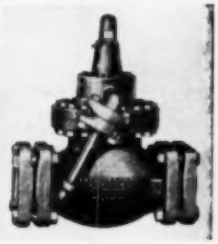
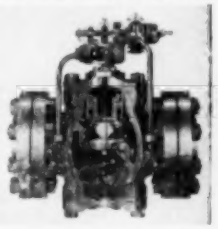


Bulletin 950—features the CASH STANDARD Type D Single Seat Pressure Reducing and Regulating Valves for use with most fluids. Shows simple inner working parts that save in maintenance. Diagram explains how valve works. Blueprint shows simplicity of installation



Bulletin 956—features the CASH STANDARD Type 4030 Back Pressure Valve — designed to automatically maintain a constant pressure in the evaporator corresponding to a constant temperature desired. Shows an Ammonia and Freon Gas Capacity Chart based on ABSOLUTE pressures.



Bulletin 966—features the CASH STANDARD Self-Contained, Pilot Operated Type 10 Pressure Reducing and Regulating Valve for use with water or air; with any gas or oil that is non-corrosive; and with refrigerating fluids such as Ammonia and Freon. Many interesting particulars explained such as: how valve works, tight seating, large capacity, no waste, no water hammer or chatter

Aliphatic Solvents

Article on pages 159-141

Aliphatic solvents of narrow boiling range are now made to round out the line of petroleum solvents by Humble Oil & Refining Co. at Baytown, Tex. These solvents are made by close fractionation of two types of charge stock, (1) a virgin naphtha stock boiling within the range of isopentane and 200 deg. F. and (2) the raffinates resulting from sulphur dioxide extraction of toluene and xylene hydroformates. The C_5-200 charge stock, which is a doctor-sweetened straight-run material consisting largely of paraffins and naphthenes, serves as the source of Solvent Naphtha No. 1 and 10 deg. hexane, while the raffinates (200-300 deg. F.) serve as the source of 10 deg. heptane, 10 deg. octane and Solvent Naphtha No. 7.

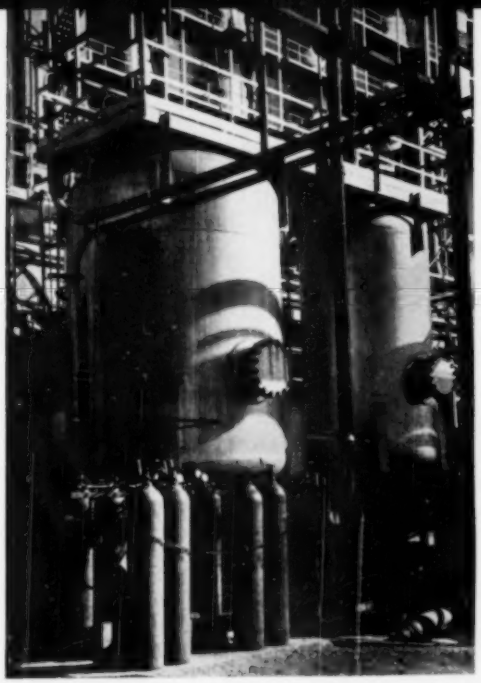
In the production of the hexane solvent the C_5-200 charge stock is preheated with steam and pumped through a series of four towers of a "superfractionation" unit. Hexane solvent is the overhead from the fourth tower, and is condensed and pumped through a caustic wash drum to remove H_2S. From the caustic drum the product is pumped through a Hoover sweetening system. Hexane solvent emerges from the sweetener as a finished product.

A portion of the C_5-200 charge stock is pumped through a Hoover sweetener in order to improve odor and then blended with toluene raffinate to produce Solvent Naphtha No. 1.

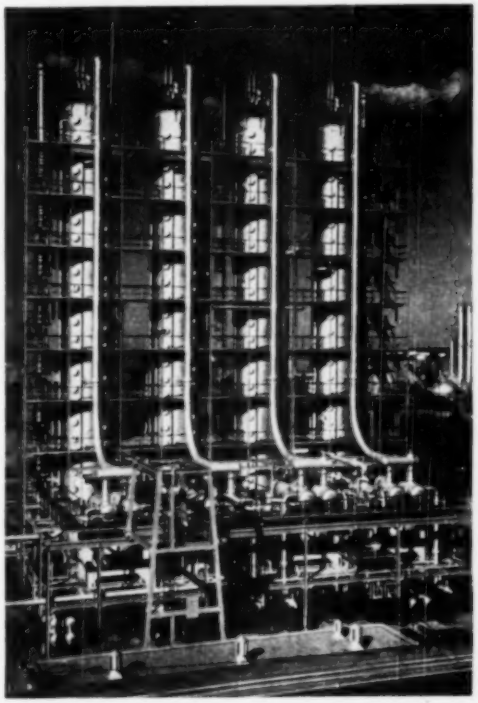
The heptane and octane solvents and Solvent Naphtha No. 7 are produced from an 80-20 blend of the raffinates resulting from SO_2 extraction during production of the toluene and xylene solvents. This material is pumped through a steam preheater and into a fractionator where the heptane vapors are removed overhead, condensed and sent to storage. Bottoms from the first fractionator are pumped into a second tower. The overhead from this tower is the octane solvent, and from one of the lower trays Solvent Naphtha No. 7 is drawn off.

Yields of the aliphatic and aromatic solvents are subject to considerable variation depending on requirements. The company expects to be producing about 1,500 bbl. per day of the aliphatics during 1949. The C_5-200 charge stock which is normally processed contains, typically, 20 to 22 percent hexane solvent. The toluene-xylene raffinate normally yields 33 percent heptane, 17 percent octane and 45 percent Solvent Naphtha No. 7.

Humble has been fractionating at times from the C_5-200 charge stock small quantities of cyclohexane. In general, the same superfractionating equipment used for the production of hexane solvent is employed, but a different piping arrangement is used. Cyclohexane production calls for a high degree of fractionation, accurate instruments and an extremely narrow range of temperature control.

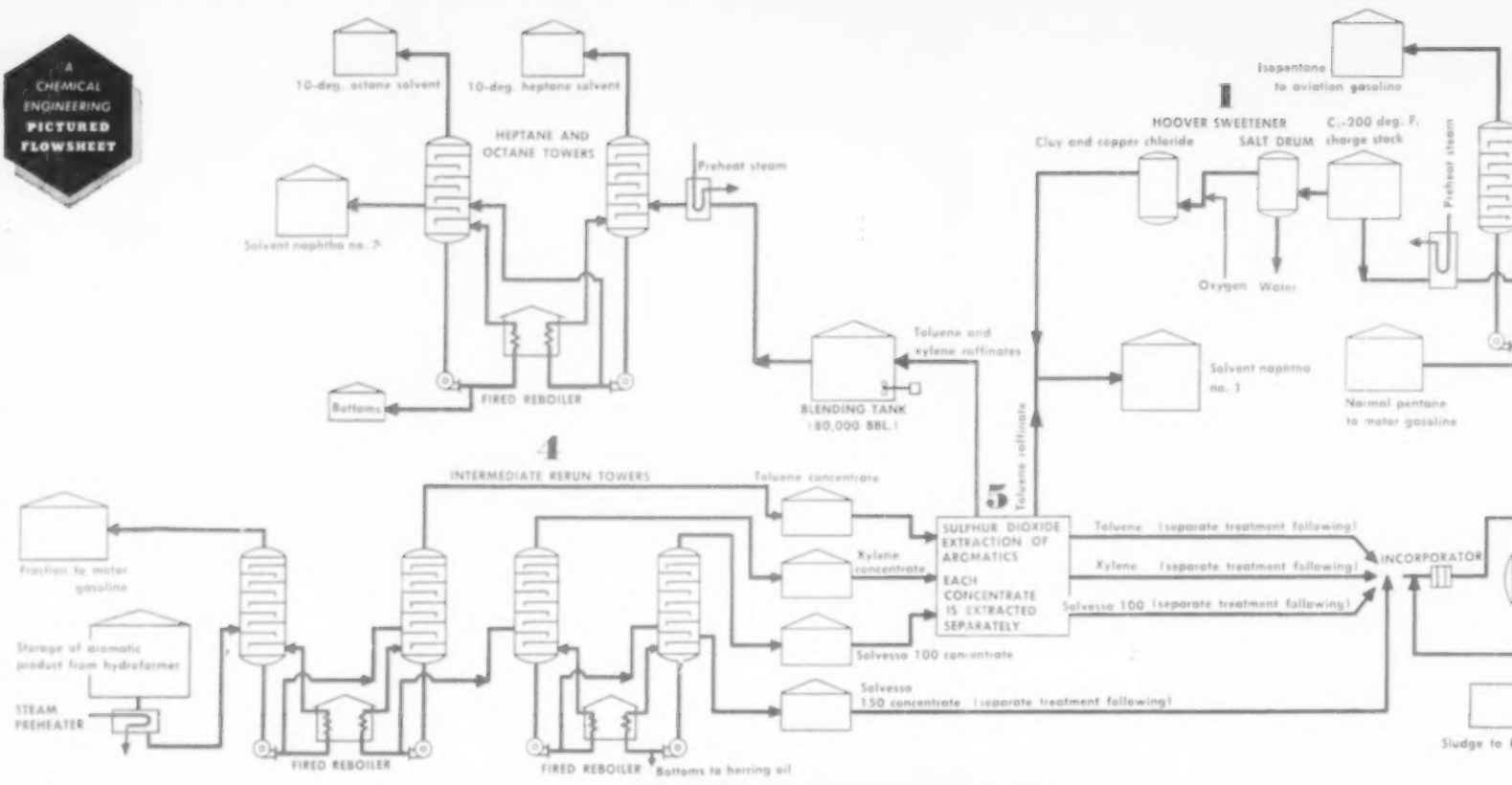


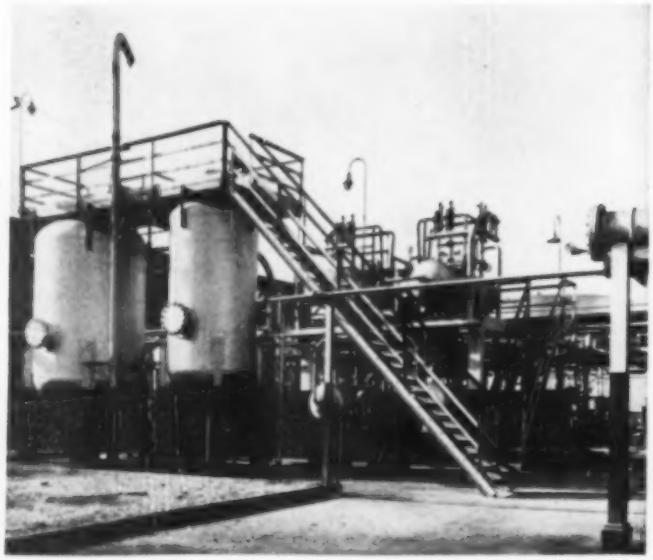
1 Hoover unit with clay drum and salt drum sweetens portion of C_5-200 charge stock to produce solvent naphtha.



2 Superfractionating unit for making aliphatic solvents. Two towers are sometimes used for heptane and octane.

A CHEMICAL ENGINEERING PICTURED FLOWSHEET

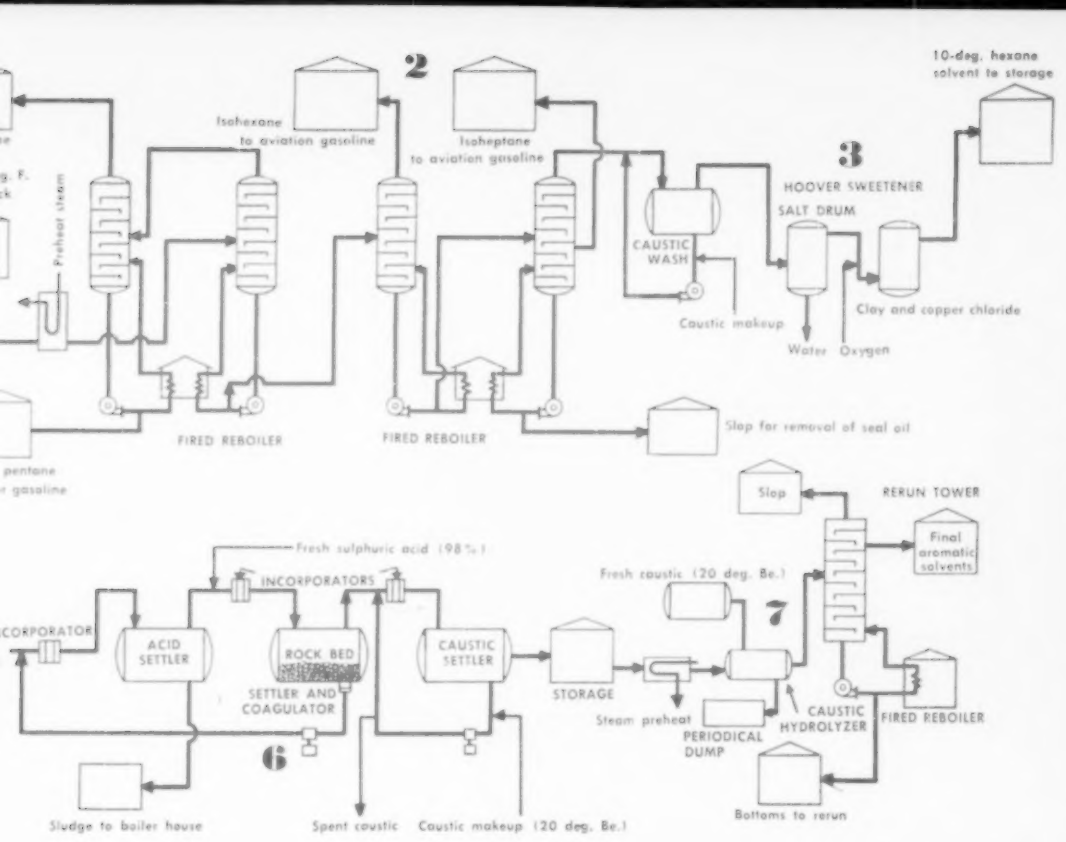


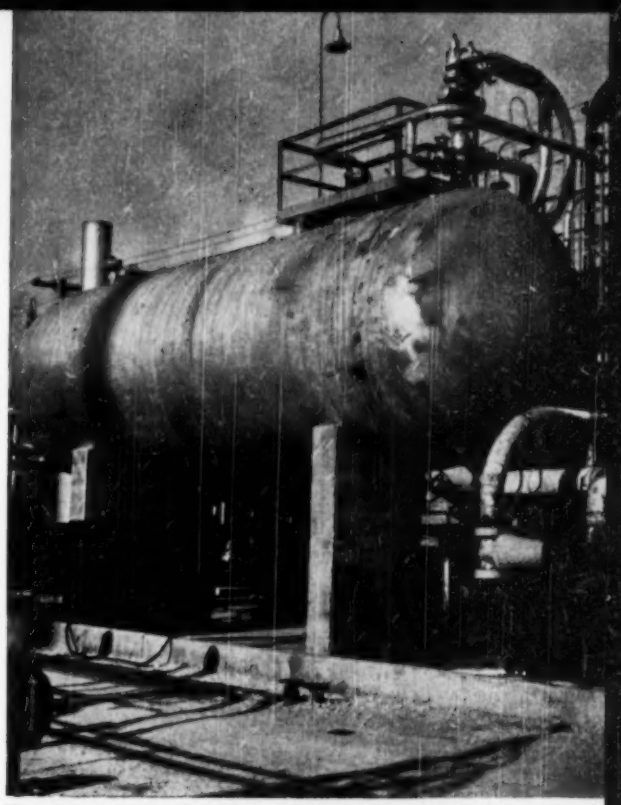


Sweetening unit for 10-deg. hexane solvent showing clay drum and salt drum at left. In background to right are drums of caustic wash equipment.

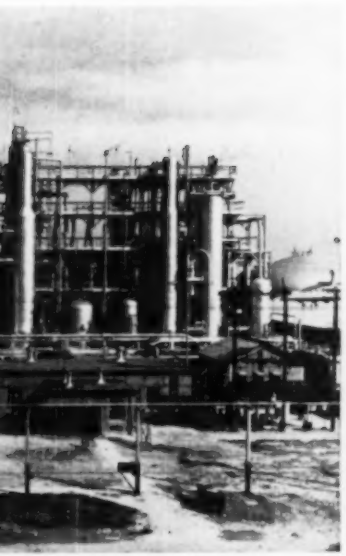
Bubble towers perform all fractionation required in preparation of feed stock for aromatics.

Extraction plant for sulphur dioxide where toluene, extracted from the concentrates of these materials.

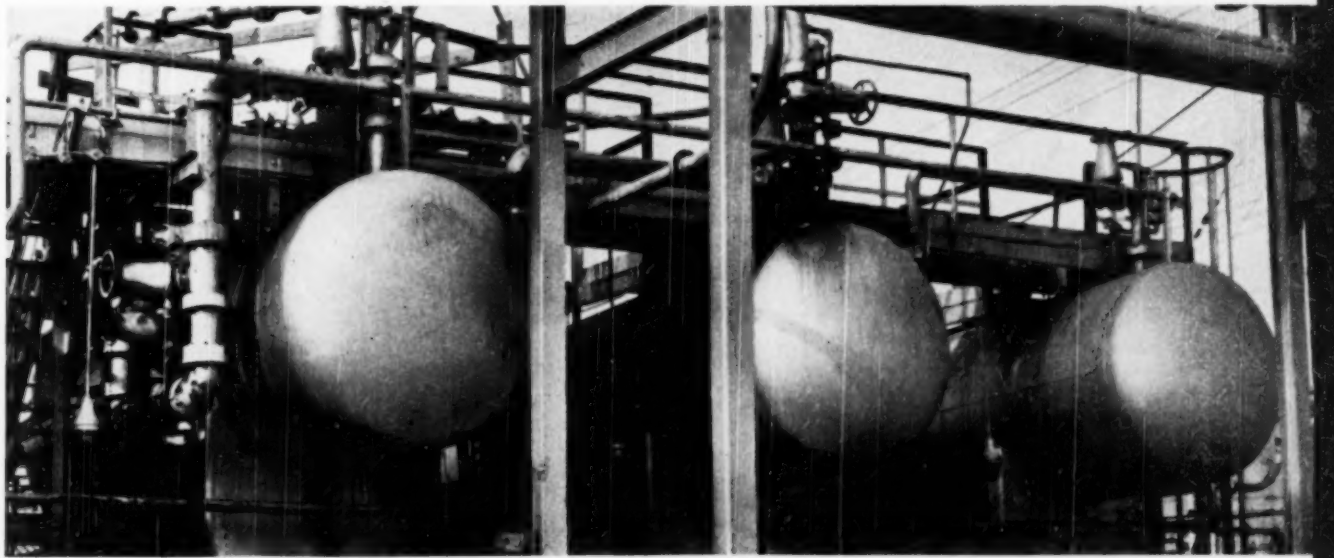




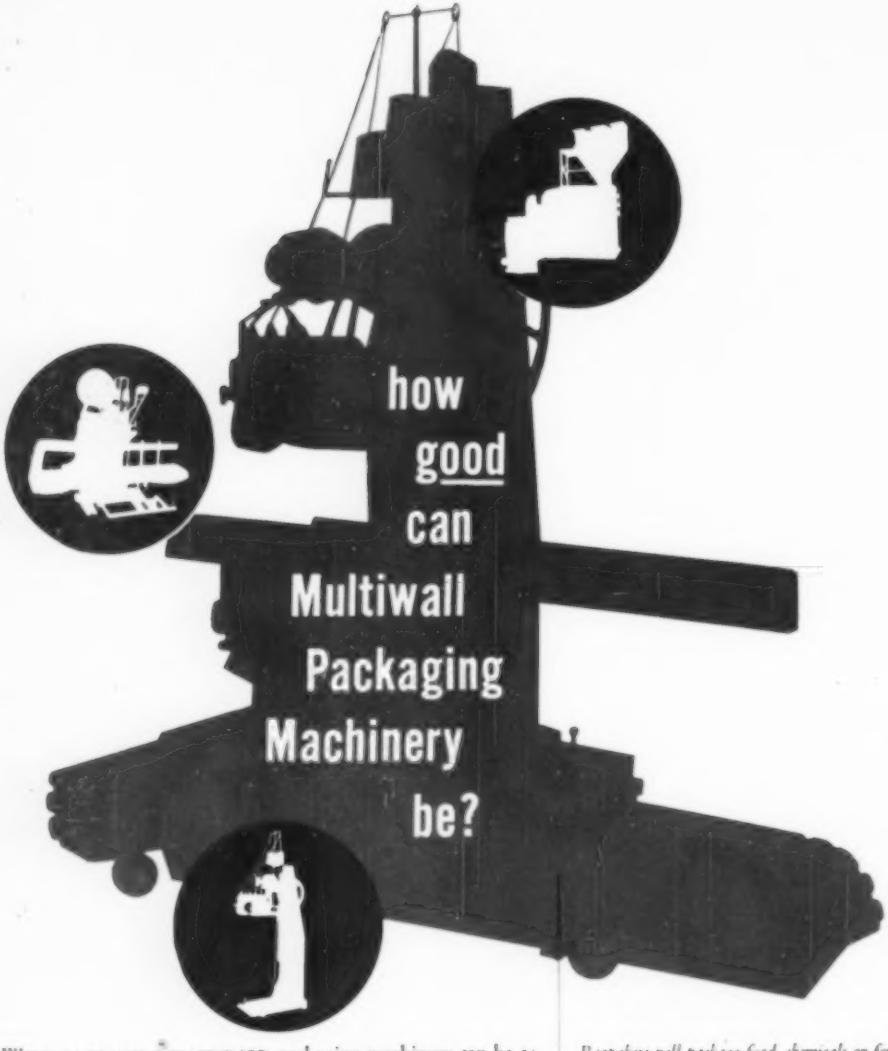
7 Hydrolyzer is used for high-temperature caustic treating of toluene, xylene, Solvessos 100 and 150 solvents.



where toluene, xylene and Solvesso 100 are ese materials.



6 Acid system for treating solvents. Equipment is conventional. The product passes through incorporator, mixed with recirculated acid, a settling drum for removal of sludge, a second incorporator with fresh acid, and into a combined settling drum and coagulator.



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In ion exchange—whether for water treating systems, as shown here, or for any other process—Crane can supply all piping equipment for your installation. Check your needs against the Crane Catalog. You'll find it offers an unequalled selection of valves, fittings, pipe and accessories—in brass, iron, steel, and alloys—available on one order to your local Crane Branch and Wholesaler.

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CRANE CO., 836 S. Michigan Ave., Chicago 5, Ill.
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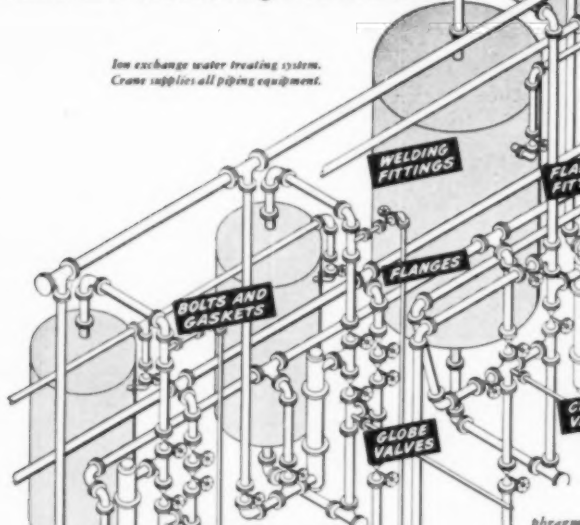
Ion exchange water treating system. Crane supplies all piping equipment.



phragm for ion Neopre seating, has longer life off even if diaphragm quires less torque; few through area in Y-P pressure drop. Full N for corrosive services. pounds, cold; maximu Sizes: ½ to 4-in. Write

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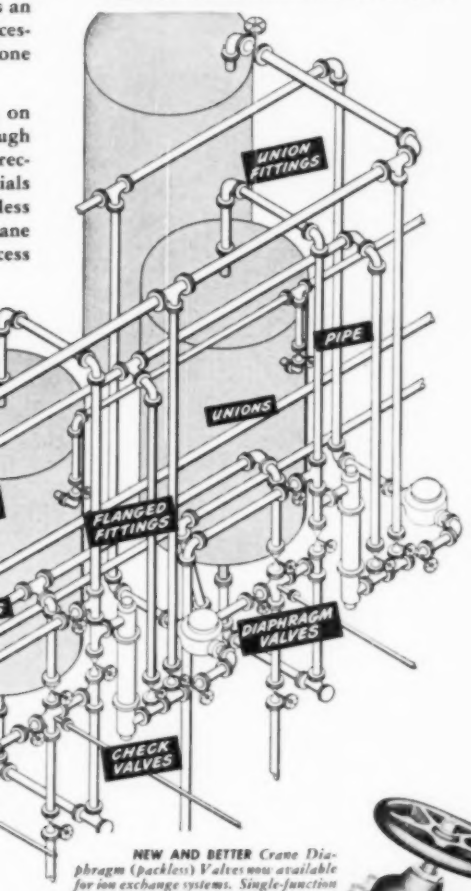

NEW AND BETTER *Crane Diaphragm (packless) Valves now available for ion exchange systems. Single-function Neoprene diaphragm, independent of ting, has longer life; permits positive shut- even if diaphragm fails. Operation re- ires less torque; fewer turns. Greater flow- ough area in Y-Pattern design lessens ssure drop. Full Neoprene-covered valves corrosive services. Working pressure: 150 nds, cold; maximum temperature 180° F. es: ½ to 4-in. Write for Catalog Ad-1761.*

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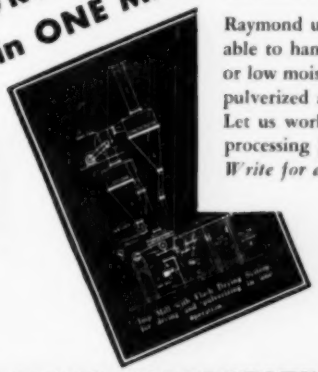

FLOW SHEET of Imp Mill with Flash Drying Equipment.

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RAYMOND PULVERIZER DIVISION
1311 North Branch Street, Chicago 22, Illinois

Process Equipment News

THEODORE R. OLIVE, *Associate Editor*

SAFE, ACCURATE:

Chlorine Dispenser

Fischer & Porter Co., Hatboro, Pa., has developed a new series of chlorine dispensers built around its Flowrator flow meter. Known as the Rato-Chlor, the device withdraws chlorine from the cylinder, drum or tank car and filters it to remove gum-forming hydrocarbons. The chlorine is then delivered to the unit at a controlled pressure of −20 in. w.g., the flow rate being set by a needle-type regulating valve as measured by the flow meter. A differential pressure regulating valve completes the flow control element. Vacuum is created by a water ejector, and kept uniform by a vacuum regulating valve. The ejector draws chlorine into its jet, mixes it with water, and discharges the dilute chlorine-water solution through a distributor into the stream being chlorinated.

The unit incorporates a vacuum-operated shut-off valve which automatically stops flow in event of leakage anywhere in the dispenser. The system can be used for either intermittent or continuous operation, and can be equipped with recording or totalizing accessories. It can easily be tied in with flow transmitters on water or sewage lines to proportion the chlorine flow automatically. Seventeen standard sizes range from maximum capacities of 10 to 7,500 lb. per day, each unit having a turn-down range of 10 to 1.

Marshall and Stevens Indexes of Comparative Equipment Costs

(1926 = 100)

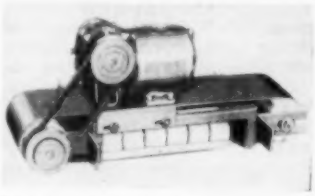
Compiled quarterly for March, June, September and December of each year by Marshall and Stevens, evaluation engineers, Chicago and Los Angeles. Indexes are prepared for 47 different industries, from which the eight process and four related industries listed here are selected. Published each month with the latest available revision. For a description of the method of obtaining the index numbers see R. W. Stevens, *Chemical Engineering*, Nov. 1947, pp. 124-6. For a listing of annual averages since 1913 see *Chemical Engineering*, Feb. 1949, p. 129.

	Mar. 1948	Dec. 1948	Mar. 1949
Industry			
Average of all	158.4	166.0	165.1
Process Industries			
Cement mfg.	152.0	159.8	159.5
Chemical	160.0	167.8	167.5
Clay products	147.0	154.8	154.5
Glass mfg.	150.1	157.9	157.6
Paint mfg.	153.3	161.1	160.8
Paper mfg.	153.6	161.4	161.1
Petroleum ind.	156.4	164.2	163.9
Rubber ind.	158.8	166.6	166.3
Process ind. avg.	154.4	165.2	164.9
Related Industries			
Elec. power equip.	161.6	169.4	169.1
Mining, milling	160.7	168.5	168.2
Refrigerating	170.6	181.3	181.2
Steam power	148.7	156.5	156.2

SAVES VAPOR LOSS:

Dome-Type Tank

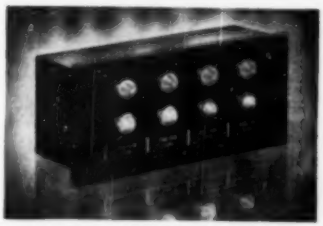
Chicago Bridge and Iron Co., 332 South Michigan Ave., Chicago 4, Ill., has developed a new dome-type storage tank designed to prevent loss of gasoline through evaporation. As shown in the accompanying view, the tank at the right is equipped with a dome section containing a flexible diaphragm made of nylon coated with Perbunan rubber, like half of a giant rubber ball. This tank, at Socony-Vacuum Oil Co.'s Worcester, Mass., plant, is the first to be built in the country. When vapors expand in the tank, as in warm weather, the diaphragm expands inside the steel dome and retains the vapors. When temperatures drop, the diaphragm contracts, but air is not drawn into storage part of the tank. However, air is always present between the outer surface of the rubber ball and the metal shell which houses it.



NON-ELECTRIC:

Self-Cleaning Separator

Dings Magnetic Separator Co., 4740 West McGeogh Ave., Milwaukee, Wis., is offering a cross-belt self-cleaning separator employing Alnico permanent magnets for the removal of contaminating iron from a wide variety of pulverized materials. The unit consists of a heavy-duty permanent magnet assembly and a motor-driven endless cross belt. The magnet holds tramp iron against the underside of the cross belt, which carries it to the side beyond the influence of the magnetic field, at which point it is discharged. The magnetic unit consists of a series of C-shaped Alnico magnets, the poles of which are secured to steel plates, and the entire assembly mounted on an aluminum face plate.



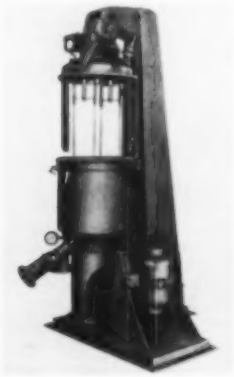
SIGNALS FOR SAFETY:

Alarm Light System

Panalarm Products, Inc., 7218 North Clark St., Chicago 26, Ill., has developed a simplified industrial signal system known as Panalarm, consisting of a box with a variable number of alarm units which can be mounted on

(Continued)

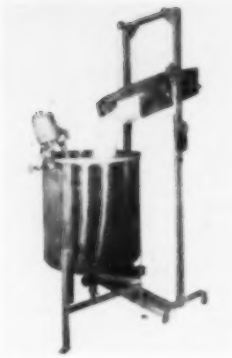
top of the regular instrument board. Each unit consists of a white light and a red light, and suitable relays. When an abnormal condition occurs, the two signal lights go on and a warning is given by a horn or other sound device. The horn is turned off and the white light goes off also when the failure is asknowledged by the operator pressing a button. The horn is thus immediately available for monitoring any other failures. The red light, however, remains lit until the original failure is corrected. Both lights glow dimly during normal operation to indicate that the signals are in an operative condition. With this system a single horn can serve for many alarms. Panalarm cabinets are available in multiple units up to 12 in a single cabinet, arranged for convenient wiring from the front.



CUTS MIXING TIME:

Heavy Paste Mixer

Abbé Engineering Co., 50 Church St., New York 7, N. Y., has announced a new stainless steel mixer for heavy pastes with triple-motion scraping and agitating mechanisms. The mixer has two sets of oppositely rotating blades in a special scraper and agitator mechanism mounted in the cover and a 600-rpm. mixing disk in the bottom which utilizes the centrifugal force developed through high-speed horizontal rotation of its curved radial ribs to disintegrate and disperse the material rapidly. Tests are said to have shown that materials ordinarily requiring a long cycle of slow mixing can be handled with saving of from 60 to 80 percent in normal mixing time. Provided with a heavy cover, the mixer can be operated under either pressure or vacuum. A jacket is available for use at higher temperatures.



SAVES LIFTING:

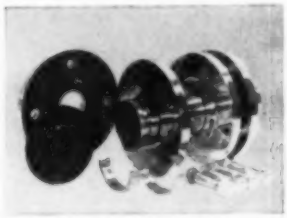
Skip Hoist for Bags

Jacob House and Sons, 52 St. Paul St., Buffalo 8, N. Y., has introduced the "Upanover," a light-weight motorized skip hoist for bags or, in a slight modification, for drums or barrels up to 250 lb. weight. The hoist is designed for discharging any flowable solid into a process vessel. Designed to customer specifications, the hoist can lift to any height from 3 to 30 ft. The bag is inserted into the skip at the floor level and opened. The hoist then lifts and dumps in less than 60 sec. The device is portable and can be adjusted for dumping angle and height.

VERSATILE, ADAPTABLE:

Jacketed Mixing Kettle

L. O. Koven & Brother, Jersey City, N. J., has developed a 4-ft. diameter by 3 ft. high ASME code welded kettle, designed for operation at 650 deg. F., with atmospheric tank pressure and 75 psi. jacket pressure. The kettle is provided with a 2-hp., 1,800 rpm. explosion-proof, motor driving through a 38-to-1 reducer to the U-type agitator which simultaneously stirs and removes material from sides and bottom of the kettle. A manhole is provided for cleaning. The contents may be blown out by air pressure at the end of the run. With slight modifications in discharge openings, agitator speed and other features, the kettle is suitable for a wide variety of operations in chemical, pharmaceutical and other process industries.



EASY TO INSTALL:

Joint for Lined Pipe

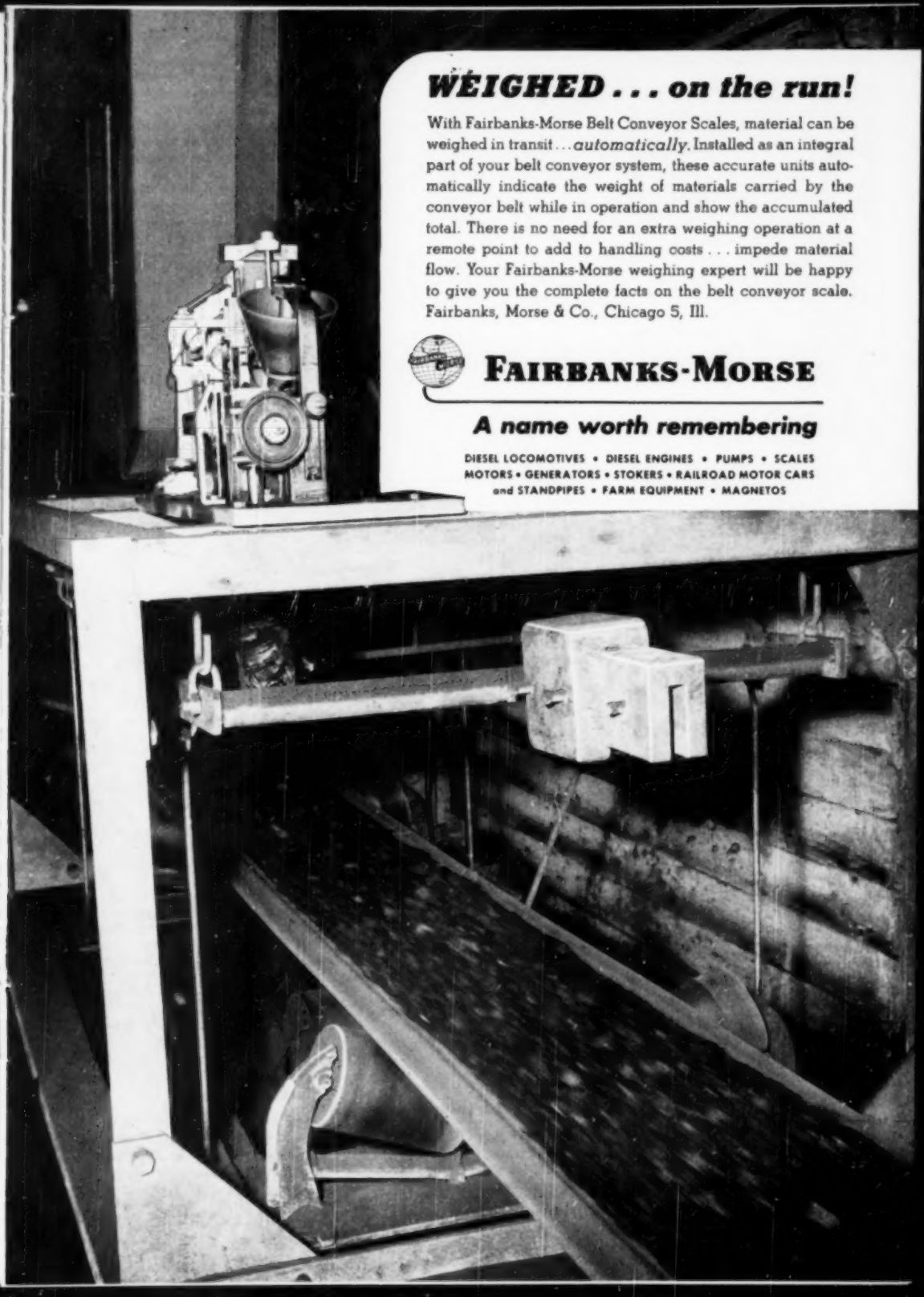
Gates Engineering Co., New Castle Ave., New Castle, Del., is offering a new pipe joint said to reduce the cost of installing and repairing rubber lined pipes by as much as 50 percent. The Gaco joint eliminates need for detailed layout plans, since lined pipe may be bought in sections, cut and installed on the job. Welded fittings are eliminated since the pipe is cut, grooved, bored and counterbored with a special machine—or a regular pipe machine equipped with an adapter. Rubber inserts are slipped into place, the flanges bolted together, and the joint is completed, it is claimed, within 2 min. These joints are available in 1¼ to 4 in. pipe size, as 45- and 90-deg. ells, Y's, tees and separate flange kits for connecting straight lengths. Equipment for adapting the user's own pipe machine is available at nominal cost, while a special machine may be bought or leased.

SAVES TIME:

Flow Slide Rule

Coleman J. Major, 2252 Fifteenth St., Wyandotte, Mich., has developed and is offering a liquid flow slide rule for solving problems in the flow of liquids in pipes and smooth-drawn tub-

(Continued)



WEIGHED . . . on the run!

With Fairbanks-Morse Belt Conveyor Scales, material can be weighed in transit . . . *automatically*. Installed as an integral part of your belt conveyor system, these accurate units automatically indicate the weight of materials carried by the conveyor belt while in operation and show the accumulated total. There is no need for an extra weighing operation at a remote point to add to handling costs . . . impede material flow. Your Fairbanks-Morse weighing expert will be happy to give you the complete facts on the belt conveyor scale. Fairbanks, Morse & Co., Chicago 5, Ill.

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ing. The rule solves the Fanning equation and may be used for calculating pressure drop, pipe diameter, or rate of flow for any liquid whose viscosity and density are known. It solves problems in either the turbulent or streamline flow region and automatically indicates which type of flow exists. Made of plastic, its scales cover the range of viscosity from 0.1 to 10,000 cp.; specific gravity from 0.2 to 20; rate of flow from 0.01 to 100,000 gpm.; and pipe diameter from ¼ to 24 in. pipe.

SELF-ENERGIZED:

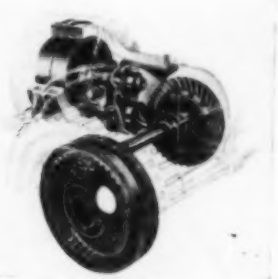
Permanent Magnet Pulley

Stearns Magnetic Mfg. Co., Milwaukee 4, Wis., is now offering a permanent magnetic pulley separator for a variety of separations of magnetic and non-magnetic materials, such as the automatic removal of tramp iron from raw or processed materials. The device uses Alnico magnets to secure uniform high magnetic strength over the entire pulley face. More than 50 sizes are available from 12 in. in diameter by 12 in. wide to 30 in. by 60 in. Because it has no wiring or electrical connections, the pulley can be operated under all atmospheric and temperature conditions.

WIDE RANGE:

General Purpose Pumps

Peerless Pump Div., Food Machinery & Chemical Corp., Los Angeles 31, Calif., is now offering its improved line of Type A general purpose pumps for water and alkaline liquids. They are available in a wide capacity range up to 60,000 gpm. against heads up to 300 ft., and are suitable for temperatures up to 300 deg. F. Made in a single-stage, double-suction, horizontal split case design, their sizes range from 1¼ to 48 in. Any type of drive may be employed. These pumps are regularly furnished in cast iron but may be obtained in steel, bronze or other alloys. The upper half of the case is provided with water seal pipes to the stuffing boxes, air vents and lifting eyes. The stuffing boxes are wide and deep, each box utilizing from five to six rings of graphited, braided asbestos packing. Impellors are generally furnished in bronze, but are available in other materials.



SIMPLIFIES CONTROL:

Magnetic-Drive Truck

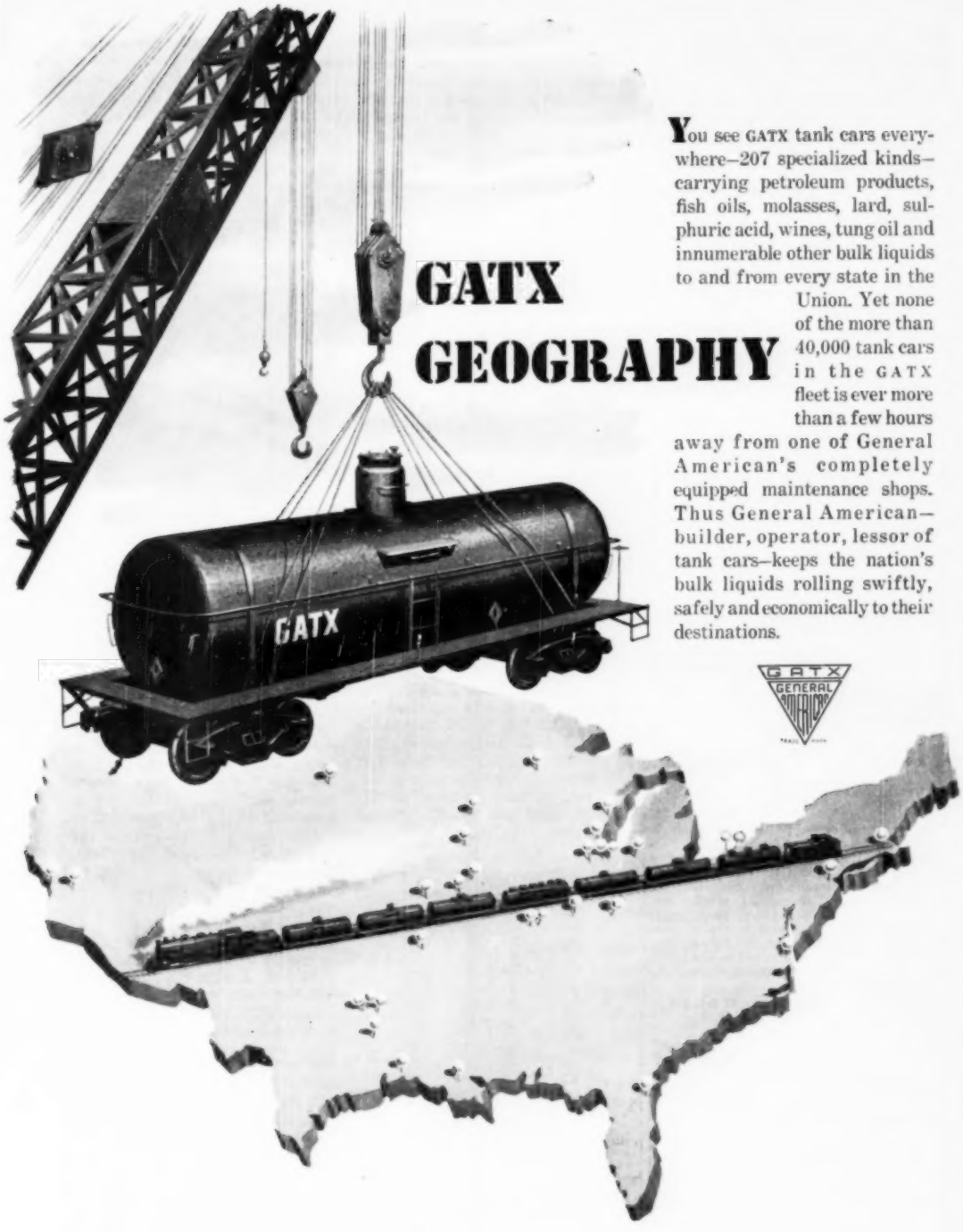
Clark Equipment Co., Industrial Truck Div., Battle Creek, Mich., has developed a gas-powered fork truck employing a magnetic induction drive, known as the Dynatork Drive. Power from the truck's engine is transmitted by magnetic induction, two magnetic coils being mounted within the flywheel and surrounded by magnetic poles. These rotate with the flywheel and are the driving members. One coil serves for forward and the other for reverse operation. The two rotors attached to a special forward-and-reverse, constant-mesh gearing are the driven members. Since the driving force is applied through an air gap, there is no metal-to-metal contact between driving and driven members (and no clutch). The system results in simplified controls and much smoother operation, according to the manufacturer.

SAFE, FLEXIBLE:

Chain Conveyor

Industrial Equipment Co., 315 North Ada St., Chicago 7, Ill., has completed development of a flexible chain conveyor system known as the

(Continued)



GATX GEOGRAPHY

You see GATX tank cars everywhere—207 specialized kinds—carrying petroleum products, fish oils, molasses, lard, sulphuric acid, wines, tung oil and innumerable other bulk liquids to and from every state in the Union. Yet none of the more than 40,000 tank cars in the GATX fleet is ever more than a few hours away from one of General American's completely equipped maintenance shops. Thus General American—builder, operator, lessor of tank cars—keeps the nation's bulk liquids rolling swiftly, safely and economically to their destinations.

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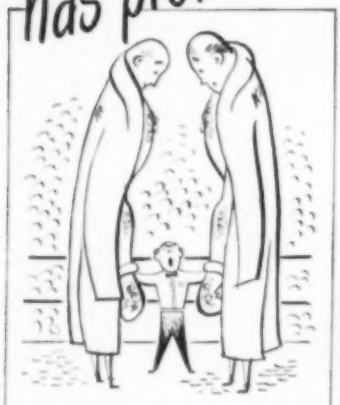

When I tap you on the shoulder . . . break clean!

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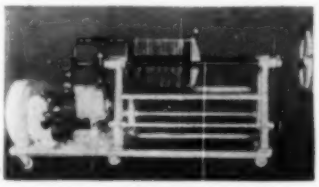
V-4

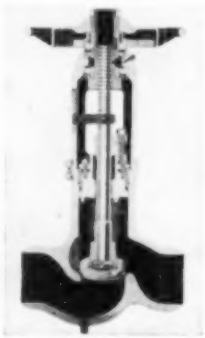
Chain-O-Flex for carrying unit loads weighing up to 50 lb., up, down or around corners. From a few standard parts any desired set-up can be assembled with a few tools, much like a child's construction set. The conveyor features corner flexibility, each corner being adjustable to any degree within liberal limits. Conveyors are provided with lifetime grease-sealed ball bearings in each corner wheel which carries the chain and load. An electric oiler, connected to the motor system, is provided to insure measured lubrication only when the system is operating. The variable-speed drive unit has a 3-to-1 speed ratio, while inclosure of the drive chain is provided to insure safety.



CORROSION RESISTANT:

Stainless Filter Press

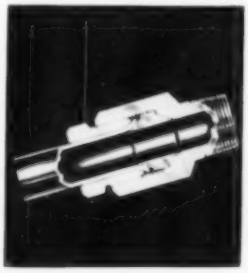
Ertel Engineering Corp., Kingston, N.Y., has developed a portable filter press of stainless steel in sanitary design, built in sizes to accommodate from 10 to 100 of this company's low-iron-and-calcium asbestos filter sheets, filter paper or filter cloth. The unit is provided with a stainless steel drip pan, pressure gage and sanitary stainless steel pump with pressure relief valve.



PRESSURE LOSS LOWER:

Cast Steel Valves

Edward Valves, Inc., East Chicago, Ind., is producing a new line of cast steel valves in globe and angle types for all sizes above 6 in. in the 900, 1,500 and 2,500 lb. classes. The valves employ either pressure-seal or bolted bonnets, but in any event are smaller and lighter, and feature drastic reduction in pressure loss as compared with earlier valves for such service. Design improvements, more even distribution of metal in the body walls and other features result in weight reduction, as well as a reduction in space occupied.



FOR CORROSIVE SERVICE:

Stainless Flared Fittings

The Special Screw Products Co., 5445 Dunham Road, Bedford, Ohio, has introduced a line of Koncentrik flared tube fittings, in Type 316 stainless steel, as well as in Carpenter No. 20 stainless. The line includes the unions, couplings, tees and elbows for line sizes to 1 in. Larger sizes are special. These fittings are designed primarily for use in lines carrying corrosive liquids and gases, or where operating shock and pressures are excessive. The design includes a patented floating seat which automatically adjusts itself to the tube flare, and insures full-circle, metal-to-metal contact. In addition, a resilient Teflon ring on each end of the floating seat serves as an extra safety seal.

PROTECTS METAL:

Hot Duct Liner

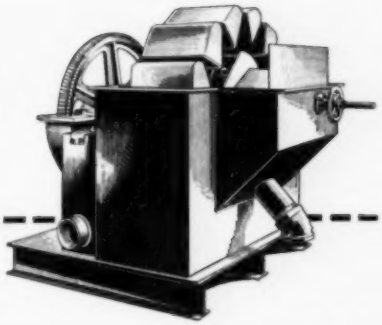
M. H. Detrick Co., 111 West Washington St., Chicago 2, Ill., has announced an insulating liner for flues, ducts and breechings, consisting of block insulation supported by a system of bars held in position by bolts welded to the steel shell. The insulation is then covered with a special cement which protects it and provides a reasonable amount of abrasion resistance. Tests up to five years are claimed to have indicated that the supporting method used eliminates maintenance and provides protection for the duct or flue at temperatures up to 1,200 deg. F. The insulation used is a block form of mineral wool, supported by special

(Continued)

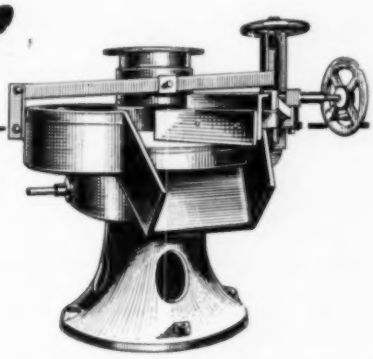
Traylor Feeders

KEEP PRODUCTION HIGH IN KILN OR MILL . . .

wet or dry . . .



Wherever wet materials must be supplied to kilns, mills or dryers, no equipment offers more complete control than a Traylor Slurry Feeder. This self-contained, fully enclosed unit is sturdily constructed of steel with all-welded joints. It is comprised of a steel disc-wheel rimmed with buckets, a constant level tank and a proportioner which diverts the flow of material to the processing equipment at any desired rate. The tank's liquid level and position of the proportioner are easily changed from outside. Built in sizes from 3′ to 6′.



The Traylor Table Feeder is designed to furnish a steady supply of any dry material, from 3″ down, to a grinding mill, rotary kiln or rotary dryer. Basically, it is a revolving horizontal table upon which a constant quantity of material is maintained by a telescoping feed spout. A swinging scraper arm removes a definite proportion of the material from the table to the processing equipment.

R.P.M. of table, height of feed spout and position of scraper are readily controlled to provide any rate of feed desired. Traylor Table Feeders are available in sizes from 2′ to 6′.

All Traylor Feeders are fully described in Bulletin 114. Write for your copy today.

TRAYLOR ENGINEERING & MANUFACTURING CO.
141 Mill Street, Allentown, Pa.

Sales Offices: New York, N.Y., Chicago, Ill., Los Angeles, Calif.

Canadian Mfrs: Canadian Vickers, Ltd., Montreal, P.Q.

TRAYLOR

TABLE AND SLURRY FEEDERS

ROTARY KILNS · COOLERS · DRYERS
GYRATORY, JAW AND REDUCTION CRUSHERS
CRUSHING ROLLS · GRINDING MILLS

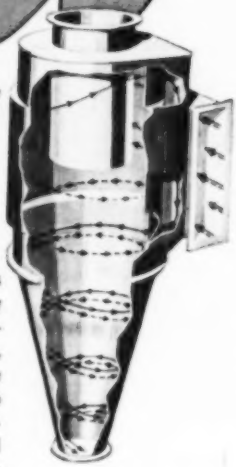
A "TRAYLOR" LEADS TO GREATER PROFITS

Simplicity...

an absolute must in

dust

RECOVERY



Complex design with many small parts multiplies the chance of trouble in any dust recovery system. The ideal equipment has no moving parts to maintain, no small passages to clog up and cause expensive shut-downs. Buell sticks to the large high-efficiency cyclone design-proportioned to each individual job. It is based upon sound aerodynamic principles which result in high operating efficiency with a minimum of turbulence and wear. An added refinement is the exclusive van Tongeren 'Shave-Off' —without which no truly efficient cyclone performance can be expected.

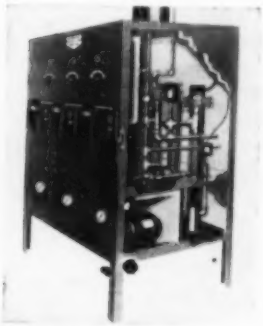
It takes a multi-page catalog to discuss the problems of collector efficiency in dust recovery. Buell publishes such a book, which is yours for the asking. Write: Buell Engineering, 18 Cedar Street, New York 5, N. Y.

buell

Engineered Efficiency in

DUST RECOVERY

T-section castings attached to the duct by studs which are quickly welded on with a welding gun available on a rental basis.



PACKAGED BTU.'S:

Heat Transfer System

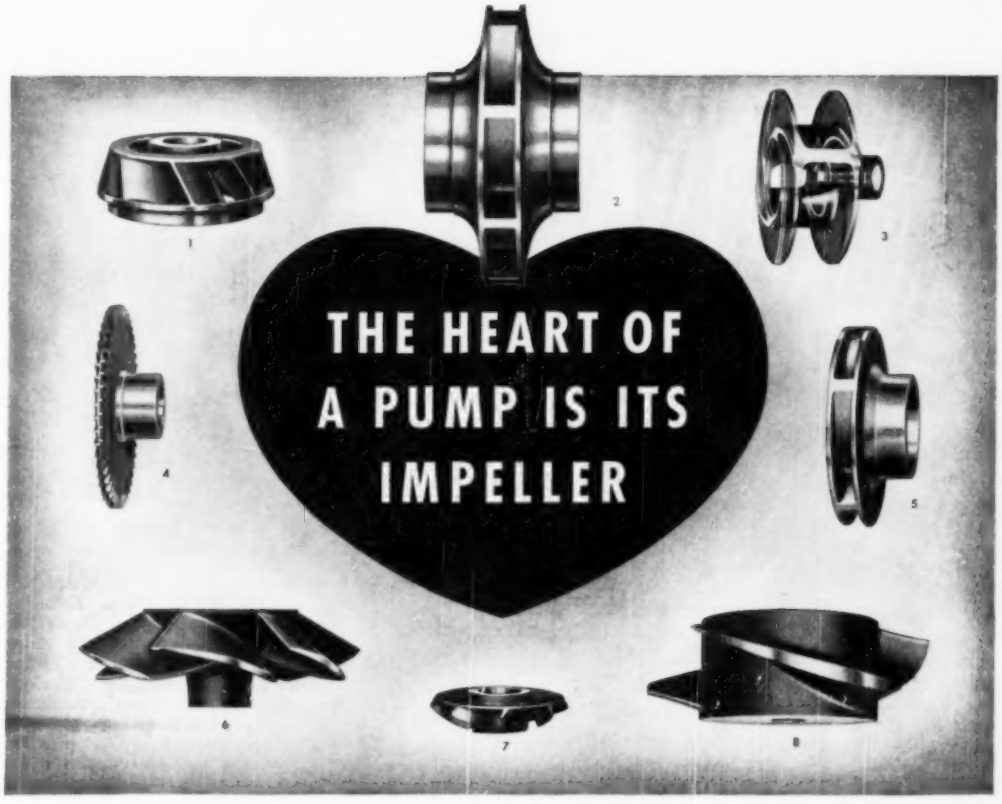
Gerin Mfg. Co., 685 Broadway, Newark 4, N. J., is now offering an electric heat-transfer system, using oil as the heat-transfer medium, for temperatures up to 600 deg. F. The device is produced in the form of a unit incorporating pump, heater, vapor release trap, expansion tank, panel and all necessary controls. The heating element, said to be a major improvement over conventional fin tube heaters, employs a large number of relatively small height fins, giving large heating area to provide low watt density with high velocity oil flow. Dual temperature controls and a heater shut-off which acts in case of low pump pressure are among the safety features included.

LOW VOLTAGE:

Safety Trouble Lamp

Etraco Mfg. Co., Woods Church Rd., Flemington, N. J., is offering an extension trouble lamp which, although it operates on any 110-volt circuit, includes a step-down transformer in the cord and uses only six volts at the bulb. The lamp is, therefore, said to be safe for use by workers in damp surroundings, eliminating any possibility of fatal electric shock. The

(Continued)



Peerless Pumps utilize many different impeller designs to meet various fluid conditions

What makes a pump "tick?" Its heart is an impeller!

Pictured above are eight Peerless impeller designs for varying fluid conditions. No. 1 forces water upward from deep wells. No. 2 is a double suction design for high capacity horizontal pumps. No. 3 pumps solids in suspension. No. 4 handles all liquids in small capacities, at high heads. No. 5 is of single suction design for process services. No. 6 combines both radial and axial flow. No. 7 is a semi-open impeller for small diameter deep wells. No. 8 is an impeller that "propels" large liquid volumes.

The point is—capacities, lifts, heads, temperatures, chemical analysis, clarity, shaft speeds are seldom common to different pump services and installations. Because fluid conditions vary, Peerless pump designers are versatile and Peerless pumps utilize this versatility in different impellers for varying fluid conditions, successfully pumping most liquids in all industries.

Peerless horizontal pumps are available for general purpose pumping, for handling sewage and other materials in suspension, for most all process services, for moving chemicals and oils, for acids and caustics and for such specialized applications as l-p gases.

Peerless vertical turbine pumps are available for lifting water from deep wells or close-coupled for wet or dry pit installation and for drainage, drydock, canal diversion and flood control services.

Plan with Peerless for all your needs for pumps. Individual descriptive Bulletins on each of the types of Peerless Pumps described above are available upon request.

Peerless
VERTICAL AND HORIZONTAL
Pumps

fmc
PEERLESS PUMPS

PEERLESS PUMP DIVISION
FOOD MACHINERY AND CHEMICAL CORPORATION
Los Angeles 31, California Indianapolis, Indiana
District Offices: New York 5, 37 Wall Street; Chicago 40, 4554 N. Broadway; Atlanta Office: Rutland Building, Decatur, Georgia; Omaha, Nebraska, 4330 Leavenworth Street; Dallas 1, Texas; Fresno, California; Los Angeles 31, California

SKILLED WORKERS WON'T WAIT... if your plant burns down

● Skilled workers go where there's a job and a pay check. Don't let a fire destroy your plant and force them to seek other employment. The rebuilding of a competent staff can cost you plenty . . . ask your personnel manager.

Safeguard your investment in skilled labor, materials, equipment and buildings by installing modern C-O-Two Fire Protection Equipment. The new C-O-Two Combination Smoke Detecting and Fire Extinguishing System is a 24 hour a day automatic fire watchman. The first whiff of smoke in a protected area sounds an alarm. Then fast, clean, non-damaging carbon dioxide blankets the fire, putting it out in seconds, before it spreads and causes extensive damage.

Whether your fire protection problem is a store, factory, ship or power plant, an expert C-O-Two Fire Protection Engineer can help you plan and install adequate fire protection equipment. Write us today for complete information. Remember fire doesn't wait . . . act now!

C-O-TWO

C-O-TWO FIRE EQUIPMENT COMPANY
NEWARK 1 • NEW JERSEY
Sales and Service in the Principal Cities of United States and Canada
AFFILIATED WITH PYRENE MANUFACTURING COMPANY

new Saf-T-Lite weighs only 4¼ lb. and is equipped with 25 ft. of heavy insulated extension cord. A larger 32-volt model to operate on a 220-volt lighting circuit is also in production.

FOR SEVERE SERVICE:

Bronze Globe Valve

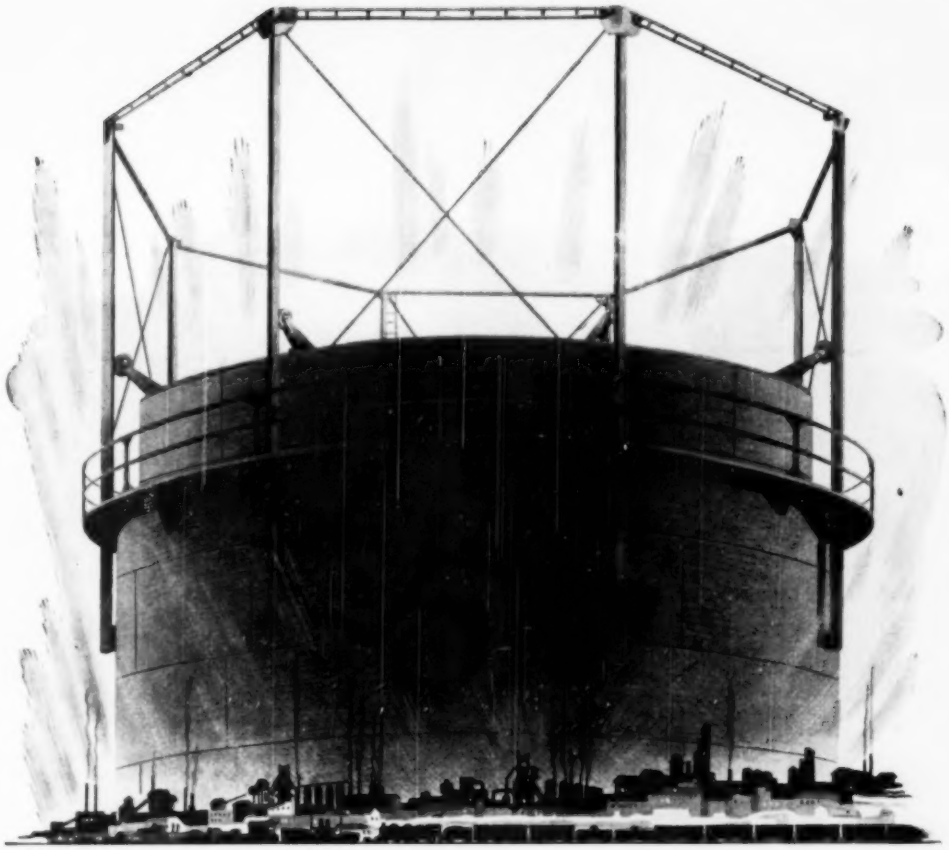
Jenkins Bros., 80 White St., New York 13, N. Y., is now offering its Fig. 976-A plug-type bronze globe valve for 300-lb. service in a variety of steam-using applications, particularly the more severe ones. The control of steam by-pass, temperature regulation and throttling of equipment are suggested applications. The valve employs a slip-on plug and a seat ring of special stainless alloy steel. The spindle is of a new corrosion-resistant aluminum bronze. Its thread is exceptionally long, and the stuffing box deeper than usual. Sizes range from ¼ to 2 in.

TAKES NO ROOM:

Under-Floor Chain Conveyor

Jervis B. Webb Co., 8951 Alpine Ave., Detroit 4, Mich., has introduced the Towveyor, a continuous chain conveyor with the chain running in a

(Continued)



Industrial Integrity

• For over forty years the Chattanooga Boiler and Tank Company has produced storage tanks and allied structural equipment for chemical and other processing industries.

During this time, each installation . . . the product of engineering ingenuity, skilled fabrication and erection efficiency . . . has served our valued customers safely, dependably and economically.

Behind the completed work of every assignment undertaken by the Chattanooga Boiler and Tank Company is the assurance of industrial integrity, the cornerstone of all our operations.

CHATTANOOGA BOILER and TANK CO.

Chattanooga, Tenn.

OVER 40 YEARS OF SERVICE TO AMERICAN INDUSTRY

STEEL SOUTHLAND PRODUCTS

General Ceramics vs. Corrosion!

IN HEAT EXCHANGE APPLICATIONS

● Where processing calls for high heat transfer coefficients plus maximum corrosion resistance, General Ceramics *Impervite* (impregnated graphite) meets every requirement.

The inherent high heat transfer of graphite plus the density imparted by impregnation with a corrosion resistant resin results in a material suited for the most stringent heat transfer applications. That's why General Ceramics *Impervite* serves best where corrosion is worst. If corrosion in heat exchange applications is your problem . . .

Here's your answer...

Send for Bulletin GR describing all standard pieces of Impervite equipment. Send specifications and drawings for special apparatus. Write for Bulletin CHE-R3 describing the full line of General Ceramics stoneware (Ceraware) porcelain (Cerawite) and impregnated graphite (Impervite).

YOU SAVE 3 WAYS WITH GENERAL CERAMICS' $$$*

Savings through uniformity of construction . . . no misfits.
Savings on shipping costs . . . one shipment for everything.
Savings on paper work, accounting . . . one order, one bill.

General Ceramics AND STEATITE CORP.

CHEMICAL EQUIPMENT DIVISION

15 Crows Mill Road — Keasbey, New Jersey

[*Sales Offices in:* BUFFALO, CHICAGO, LOS ANGELES, PITTSBURGH, PORTLAND, ORE., SAN FRANCISCO, SEATTLE, TACOMA, MONTREAL, TORONTO, VANCOUVER, B. C.]

Our Insulator Division Manufactures Steatites, Porcelains, Titanates, Ferrites

*Single Source of Supply.

3556

steel slot below the floor. It may be used to power standard four-wheel trucks or trailers, or standard two-wheel trucks if used with a dolly. Trucks are set in motion by dropping the driving pin into the floor slot. One of the pusher dogs spaced at suitable intervals on the chain engages the pin and moves the truck along the route. The trucks are disengaged simply by lifting the pin and may then be pushed away from the slot as with any hand push truck. The conveyor chain is continuous and is looped around the warehouse or other area to be served, including freight loading and unloading docks, check points, etc.

SELF-OPERATED:

Cooling Control

Sarco Co., 350 Fifth Ave., New York 1, N. Y., is now supplying a new temperature control for cooling water systems, suitable for use with condensers, engine and compressor jackets and similar applications. The device is a self-operated, rigid-stem type temperature regulator which functions by limiting the flow of cooling water, depending on the temperature of the warm water flowing over the bulb. Made in sizes from ¾ to 1¼ in., for water pressures to 150 psi., it uses a double-seated valve to provide accurate control without danger of sticking or chattering.

WIDE LOAD RANGE:

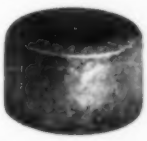
Tensile Tester

Instron Engineering Corp., 2 Hancock St., Quincy 71, Mass., is offering a tensile tester for making load-elongation measurements on plastics, paper, rubber, adhesives and similar specimens. The full scale load range of the unit extends from 2 grams up to 5,000 lb. in some models, representing a

(Continued)

Toothed Lock Washer: Prevents loss of stem nut due to vibration, thereby holding the handwheel securely.

Newly Designed Handwheel: Air-cooled, finger grip handwheel affords sure grip even with greasy gloves.



Improved Packing: Molded packing of lubricated asbestos reinforced with copper wire. Suitable for practically every service. Valves can be repacked under pressure.

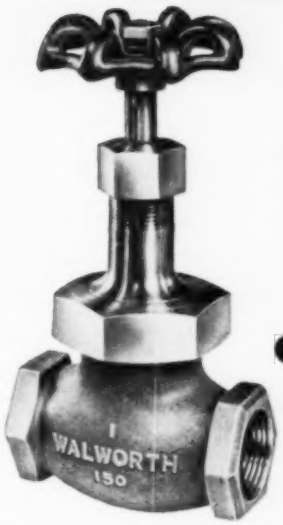
Hexagonal Union Bonnet Connection: Eliminates any chance of distortion or leakage even though valve is repeatedly taken apart and assembled.

New Cylindrical Disc Holder: The design of the top portion of the disc holder keeps the disc accurately guided under all operating conditions.

Renewable Asbestos Disc: This disc is suitable for steam up to 500F and is resistant to oil, gasoline, and many chemicals at atmospheric temperatures. Discs for special services are available.

Extra Strong Body: Made of Composition M (ASTM B61) bronze thick enough to provide a high safety factor. Valves undergo hydrostatic shell test of 450 psi.

WALWORTH



IMPROVED
No. 95
BRONZE
GLOBE VALVE

also available in Angle Type (No. 96)

The service ratings of the Walworth No. 95 are 150 pounds per square inch steam at 500F, and 300 pounds per square inch non-shock cold water, oil, and gas. In the manufacture of this quality bronze valve, more than 47 gages are used in machining parts to micrometric accuracy, thus insuring interchangeability of parts. For further information see your local Walworth distributor, or write: Walworth Company, 60 East 42nd St., New York 17, N. Y.

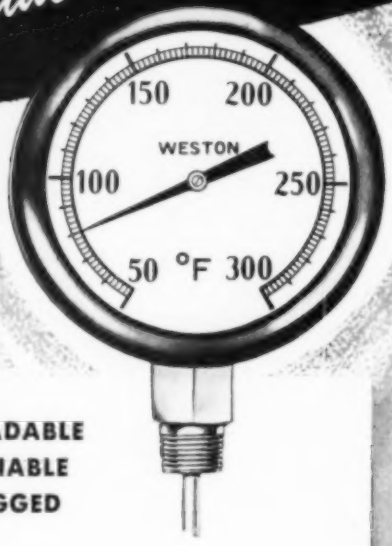
note these 7 Great Features

WALWORTH
valves and fittings

60 EAST 42nd STREET NEW YORK 17, N. Y.

DISTRIBUTORS IN PRINCIPAL CENTERS THROUGHOUT THE WORLD

Prescription for industrial temperatures



Rx READABLE RELIABLE RUGGED

WESTON

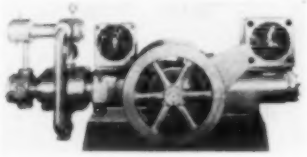
All-Metal Thermometers

Rugged, all-metal construction . . . stainless steel stems . . . bold, readable dials . . . accuracy within 1% over the entire scale—all add up to the answer to industry's toughest temperature measurement requirements. Choose a dependable WESTON thermometer from a variety of types, stem lengths and scale ranges. Call your jobber, your WESTON representative, or write for Thermometer Bulletin . . . WESTON Electrical Instrument Corporation, 590 Frelinghuysen Avenue, Newark 5, New Jersey.

CONTACT MAKING models for alarm or control purposes.
MAX-MIN models to indicate highest or lowest temperature reached.

WESTON Instruments

spread of approximately a million to one. Jaw speeds range from 0.02 to 20 in. per min. The instrument utilizes an electronic weighing system based on the electric strain gage principle for detecting and recording the load. An unusual drive for the pulling jaw provides a controlled rate of elongation of the sample over a wide range of speeds. The recorder chart is driven at various speed ratios with respect to the jaw so that tensile load-elongation curves are made accurately at a constant rate of elongation. Practically instantaneous reversal is possible for making hysteresis measurements under cyclic conditions. Available chart speeds provide magnification ratios up to 1,000 to 1.



FUEL INTERCHANGEABLE:

Two-Stage Compressor

White-Roth Machine Corp., Lorain, Ohio, is offered a new direct-connected, engine-driven, two-stage gas or air compressor known as Lorain Model O-10TS. Designed to compress large volumes, its low and high stage compressor cylinders are driven from a multi-fuel engine. It may be operated either on diesel oil or on natural gas or butane, the necessary equipment changes for switching fuels requiring approximately 90 min. The engine power cylinder is cooled by circulating water, or by a condenser-type system incorporating a belt-driven fan; the compressor has a length of 149 in., a height of 62 in., a width of 39 in., and weighs 8,000 lb.

FOR SEVERE SERVICE:

Fused-On Coating

Fusion Metal Coating Co., 21820 West Eight Mile Road, Detroit, Mich., has developed a new process for applying coating metals to base metals for protection against wear, corrosion and oxidation. The coating is fused on, both coating metal and base metal being either a pure metal or an alloy. Materials may be either ferrous or non-ferrous. However, the base metal must have a higher melting point than the coating. Coating thickness may be controlled accurately between 0.0005 and 0.020 in.,

(Continued)

KEEPS TAR "ON TAP" AT 400°F

Penflex interlocked flexible metal hose tops a hot tar handling problem, quickly, efficiently

Solved—another "hot" problem, typical of how Penflex "Flexineering" provides the *right* recommendations for economical, flexible transmission of hot liquids, chemicals, steam, air . . . for *all* industries.

With the help of Penflex engineers, one roofing equipment manufacturer developed a unique method of passing hot tar from heater on ground level up to the roofing crew. Using 1½" Penflex interlocked metal hose, a tar circulating system was designed, from heater to roof tank . . . leak-proof and safe.

Hot tar is now on tap at 400°F., ready for quick application. Steady temperature is maintained . . . work is speeded . . . accidents are reduced. Flexibility of Penflex hose allows free movement of tar heater and roof tank.

Yes—Penflex "Flexineering" (the science of engineering each type of flexible tubing to the problem) is ready and willing to solve problems for all industries, whether they pertain to product design, production, or maintenance. For prompt, efficient service on precision-made flexible metal hose, tubing, and couplings from ⅛" I.D. to 30" I.D., write today to . . .

PENNSYLVANIA FLEXIBLE METALLIC TUBING CO.

7234 Powers Lane **Philadelphia 42, Pa.**

BRANCH SALES OFFICES—BOSTON • NEW YORK • CLEVELAND • CHICAGO • HOUSTON • LOS ANGELES

Penflex... HEART OF INDUSTRY'S LIFE LINES

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THE *Versatile* VERSENES*...

. . . can make your products (and processes) better!

VERSENE Fe-3* . . .

The powerful new sequestrant — does more than soften water without precipitation. It actually inactivates troublesome trivalent iron as well as calcium, magnesium and other metallic salts. Until VERSENE Fe-3 was developed, there was no really satisfactory sequestering or chelating agent for ferric iron. At pH7 10 cc of Versene Fe-3 sequesters at least 167 mg. of Fe_3 plus 158 mg. of calcium. Above pH9 it is most effective on alkaline earth ions.

VERSENE* (REGULAR)

Is the tetra sodium salt of Ethylene diamine tetra acetic acid and is available in solution or powdered form. Extremely versatile, economical and efficient, it may be used to do a variety of things such as:

- Softening Water Without Precipitation
- Removing Hard Water Deposits And Precipitates
- Dissolving Grease And Food Deposits
- Clarifying Liquid Soap Solutions
- Preventing Oxidation Of Fats, Oils, Soaps, Fatty Acids, Organic Materials
- Stopping Reactions Catalyzed By Metallic Ions
- Aiding In Purification Of Materials
- Separating Metals From Each Other
- Reducing Activity Of Metal Ions

VERSENE* is a pale, clear, straw-colored aqueous solution with *total solids* approximating 34%. It has an approximate *density* of 1.2 and an approximate pH of 11.75 in a 1% solution. VERSENE* is also available in crystalline form as a dry white powder. Send for Technical Bulletin No. 1. Ask for Fe_3 Data Sheet. Samples on request.

*Trade Mark

BERSWORTH CHEMICAL COMPANY
Framingham, Massachusetts

depending on requirements. Contours and inside surfaces can be coated, and coatings can be applied to any desired area with the uncoated base metal protected from oxidation during fusion. Refractory coatings, with lower melting point metals serving as binders, can be applied to give highest possible abrasion resistance. Parts may be heated for fusion in a furnace, or by induction, or by a preferred method involving a liquid bath developed especially for the process.

NO FLYING SPLINTERS:

Gage Glass Protector

Wright-Austin Co., 315 West Woodbridge St., Detroit 26, Mich., is offering a new type plastic protector for gage glasses on boilers and process equipment. Known as the No. 28 Kleervu, it will fit any gage in which the dimension of the packing nut does not exceed 1⅝ in. across the hexagon. It completely incloses the glass, with a metal guard on the back of the glass, and a clear plastic protector on the front. Any height from 4 in. to 8 ft. can be provided, installation taking only a few minutes. The ¼ in. thick plastic used is said to have the optical qualities of plate glass, yet to be shatterproof.

Briefs . . .

CRAWLER HAND TRUCK. Associated Services, 224 West Main St., Carlinville, Ill., has announced a lightweight hand truck which, in addition to its usual wheels, is provided with a crawler tread mounted above and behind the wheels to permit the truck to be rolled up and down steps easily. The truck comes in a number of models, both wood and metal.

BELLOWS SAFETY VALVE. Farris Engineering Corp., 458 Commercial Ave., Palisades Park, N. J., has incorporated a bellows seal in a safety valve in such a way that the lading fluid is completely isolated from the valve spring chamber and guide surfaces. This feature is said to eliminate an important cause of failure in safety relief valves, which are often affected adversely by corrosive attack on the valve spring. The bellows is of stainless steel and is also available in rubber or neoprene where required for corrosion resistance.

TRUCK DEVELOPMENTS. The Yale & Towne Mfg. Co., Philadelphia Div., Philadelphia 15, Pa., has

(Continued)

A BIG FACTOR IN Reduced OPERATING COSTS

For Acids

A Companion to the Famous WILFLEY Sand Pump

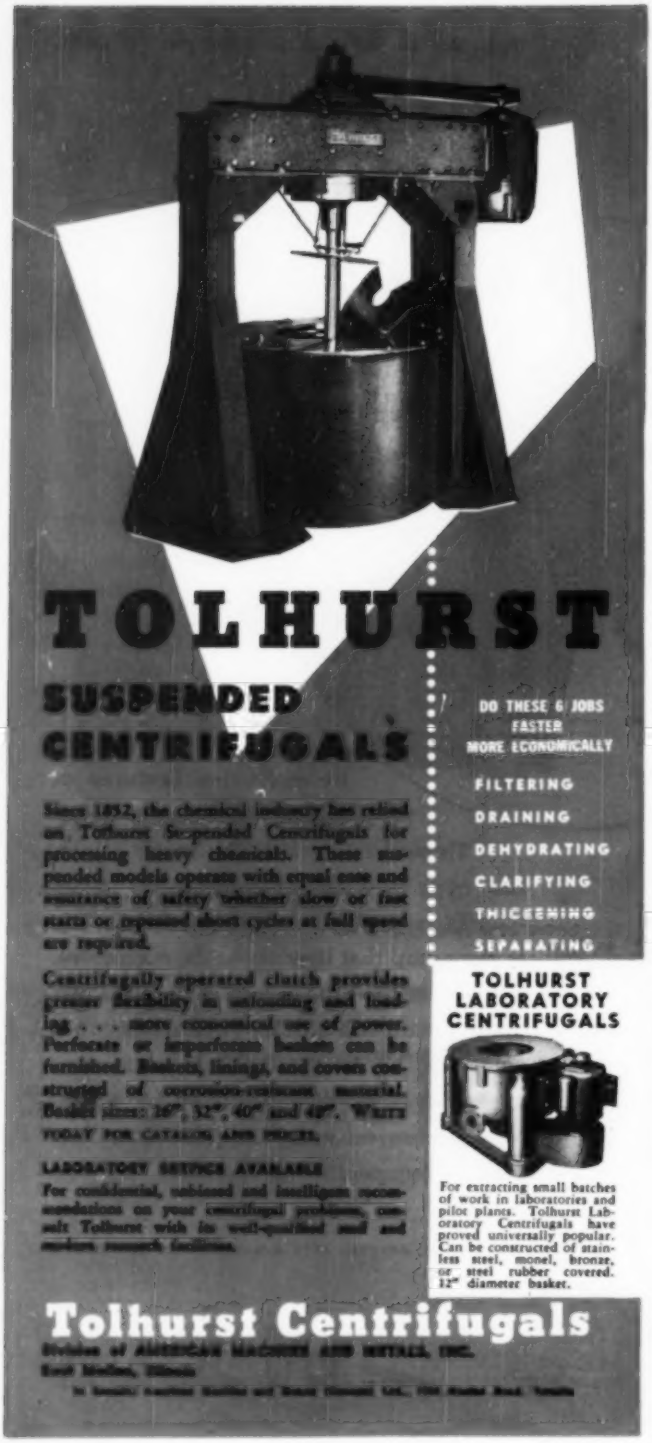
•

Buy WILFLEY for Cost Saving Performance

WORTHWHILE savings, made possible by exclusive features of the WILFLEY Acid Pump, are reflected in consistently lower operating costs of WILFLEY installations in the world's most efficient chemical plants. This is the pump that handles acids, corrosives, hot liquids and mild abrasives on a trouble-free, 'round-the-clock schedule *without attention.* 10- to 2,000-G.P.M. capacities; 15- to 150-ft. heads and higher. Individual engineering on every application... *Write or wire for specific information.*

A. R. WILFLEY & SONS, INC., DENVER, COLO., U.S.A.
NEW YORK OFFICE: 1775 Broadway, New York City

WILFLEY *Acid* PUMPS


TOLHURST
SUSPENDED CENTRIFUGALS
DO THESE 6 JOBS FASTER MORE ECONOMICALLY
FILTERING
DRAINING
DEHYDRATING
CLARIFYING
THICKENING
SEPARATING
Since 1852, the chemical industry has relied on Tolhurst Suspended Centrifugals for processing heavy chemicals. These suspended models operate with equal ease and assurance of safety whether slow or fast starts or repeated short cycles at full speed are required.
Centrifugally operated clutch provides greater flexibility in unloading and loading . . . more economical use of power. Perforate or imperforate baskets can be furnished. Baskets, linings, and covers constructed of corrosion-resistant material. Basket sizes: 26", 32", 40" and 48". WRITE TODAY FOR CATALOG AND PRICES.
LABORATORY SERVICE AVAILABLE
For confidential, unbiased and intelligent recommendations on your centrifugal problems, consult Tolhurst with its well-qualified staff and modern research facilities.
TOLHURST LABORATORY CENTRIFUGALS
For extracting small batches of work in laboratories and pilot plants. Tolhurst Laboratory Centrifugals have proved universally popular. Can be constructed of stainless steel, monel, bronze, or steel rubber covered. 12" diameter basket.
Tolhurst Centrifugals
Division of AMERICAN MACHINE AND METALS, INC.
East Moline, Illinois

NEW EQUIPMENT, cont . . .

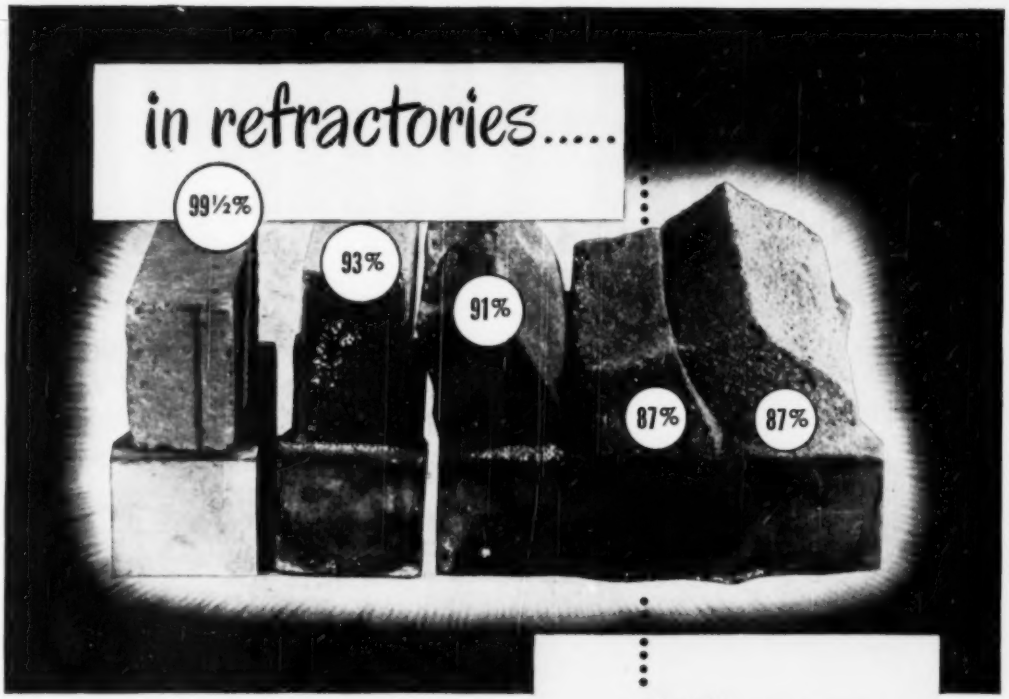
announced two recent developments in the field of lift trucks. The company has now amplified its line of electric-drive trucks with a gas truck series, featuring fluid drive, automatic controls, hydraulic piston lift in two stages by means of a ram-within-a-ram, and low mast heights with high free lifts. In addition, the same manufacturer is offering a whole new line of electric lift trucks, employing hydraulically-operated truck attachments, and provided with a two-stage hydraulic lifting system employing the ram-within-a-ram principle. Both lines of trucks have been given the name Lift-King. Both types feature sit-down operation and low mast heights.

PILOT DRUM DRYER. The F. J. Stokes Machine Co., 5920 Tabor Rd., Philadelphia 20, Pa., has announced its Model 214-A pilot plant drum dryer which has a 2 ft. diameter drum with a 2 ft. face. The equipment is extremely flexible and can be used as a single-drum dryer or flaker, or as a double-drum dryer or flaker. Drums operate at pressures up to 160 psi. and are available in a wide variety of metals. They can be heated by steam or other cooling media, or cooled with water for flaking or chilling. Variable-speed drive and complete instrumentation are provided.

VACUUM CONTAINER. The Emil Greiner Co., 20-26 North Moore St., New York 13, N. Y., has developed a line of stainless steel containers insulated with high-vacuum double-wall construction, in sizes from 1 qt. to 11 gal. The containers are unbreakable and provided with vacuum-insulated covers.

SMALL VENTURI. Republic Flow Meters Co., 2240 Diversey Parkway, Chicago 47, Ill., has announced a line of fabricated venturi tube assemblies for line sizes between ¾ and 2 in., supplied with welding ends and furnished in steel, stainless steel, or a variety of weldable alloys. These meters are particularly useful where line velocities are too high for convenient use of orifice plates.

ROTATING PRESSURE JOINT. Perfecting Service Co., 6140 Cottage Grove Ave., Chicago 37, Ill., is offering its improved Type S rotary pressure joint for temperatures up to 600 deg. F., and pressures to 150 psi. The device is intended for providing steam to rotating cylinders, and for removal of condensate. A graphite seal is used, with ball bearing rotating parts.



ALCOA Alumina increases stability and high-temperature resistance of refractories. This is clearly shown in the specimens illustrated above. All are alumina-content brick, and all were held at a temperature of *3400° F.* (Cone 40, flat) for four hours. From left to right, the alumina content of each brick is: 99½%, 93%, 91%, 87% and 87%. You can see what a "whale of a difference" a little extra ALCOA Alumina makes. (As temperatures and alumina content are decreased, similar results are obtained.)

Whatever your operating temperatures, you'll have less costly down time as a result of too-frequent refractory replacement, when you use alumina refractories. They give you these money-saving qualities:

- **Strength and stability under load at high temperatures.**
- **Resistance to spalling, abrasion and fluxing at high temperatures.**
- **Resistance to corrosive slags and gases.**
- **Negligible porosity and shrinkage.**

a little more Alcoa Alumina makes a "Whale of a Difference"

(Photo and data: Courtesy of Richard C. Remmey Son Co.)

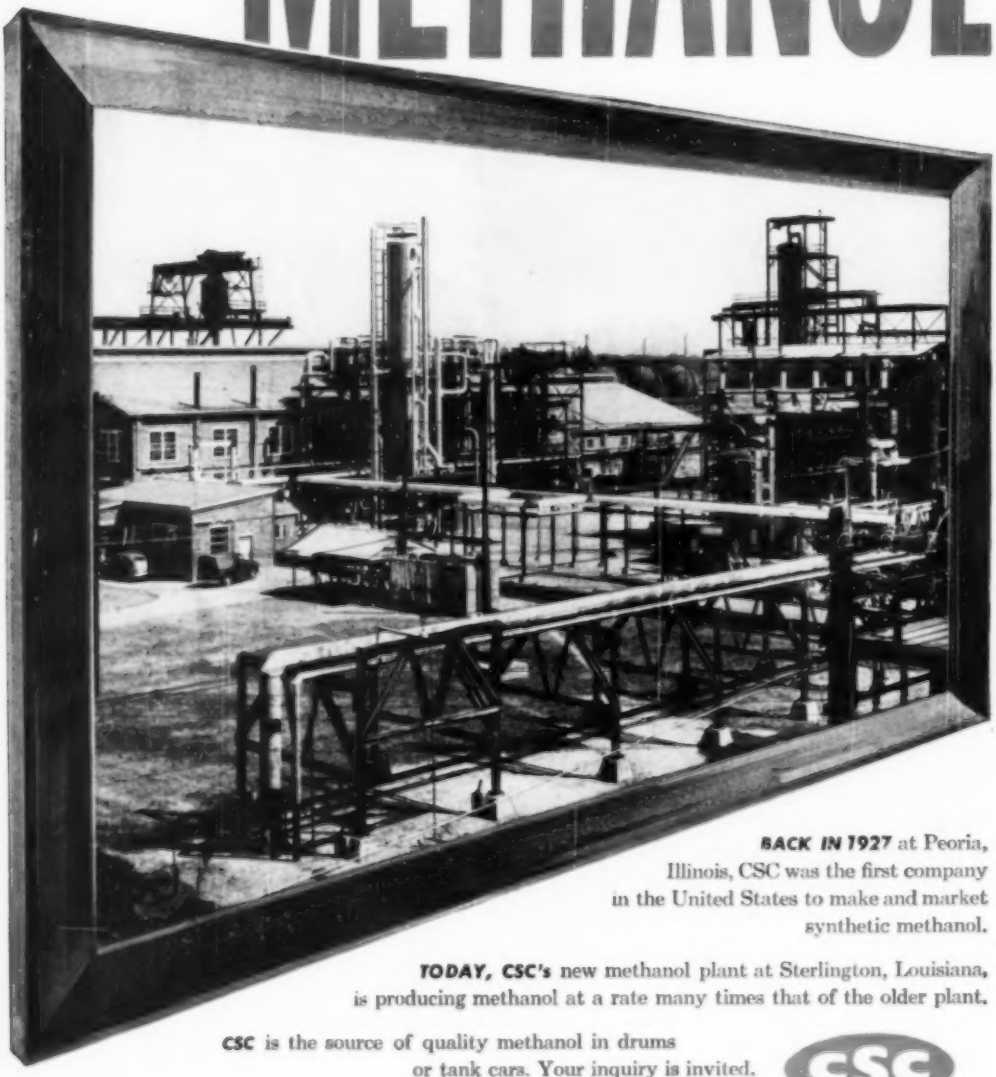
Buy from your refractory manufacturer—You can buy brick and other shapes, containing various percentages of ALCOA Alumina to meet your requirements, from leading manufacturers. We'll gladly refer you to dependable sources of supply. Write to: ALUMINUM COMPANY OF AMERICA, CHEMICALS DIVISION, 1778 Gulf Building, Pittsburgh 19, Pa.

ALCOA

ALCOA ALUMINUM

ACTIVATED ALUMINAS • CALCINED ALUMINAS • LOW SODA ALUMINAS • TABULAR ALUMINAS • HYDRATED ALUMINAS
ALUMINUM FLUORIDE • SODIUM FLUORIDE • SODIUM ACID FLUORIDE • FLUOBORIC ACID • CRYOLITE

METHANOL



BACK IN 1927 at Peoria, Illinois, CSC was the first company in the United States to make and market synthetic methanol.

TODAY, CSC's new methanol plant at Sterlington, Louisiana, is producing methanol at a rate many times that of the older plant.

CSC is the source of quality methanol in drums or tank cars. Your inquiry is invited.

CSC

COMMERCIAL SOLVENTS CORPORATION

INDUSTRIAL CHEMICAL DIVISION · 17 EAST 42ND STREET, NEW YORK 17, N. Y.

CHEMICAL PRODUCTS FOR FACTORY, FARM, HOSPITAL, AND HOME

New Products and Materials

JOSEPH A. O'CONNOR, Assistant Editor

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OXO OFFSPRING:

Long-Chain Alcohol

E. I. du Pont de Nemours & Co., Wilmington 98, Del., through its Ammonia Dept., is making available for the first time in commercial quantities trimethylhexanol, a long-chain alcohol with a variety of industrial applications.

Trimethylhexanol is made by high-pressure synthesis from the elements of coal, petroleum, air and water. This new alcohol is accordingly a distant cousin of the synthetic methanol widely used in automotive anti-freezes.

Technically known as 3,5,5-trimethylhexanol-1, the new alcohol is a colorless mobile liquid of mild odor. As manufactured, it is a single substance of high purity and not a mixture of isomers. It has a boiling point of 374 deg. F., and is not soluble in water.

Trimethylhexanol undergoes many chemical reactions, yielding compounds which are expected to find important commercial uses. For example, this alcohol reacts with certain other organic compounds to give products which appear promising as synthetic lubricants, as additives to lubricating oils to prevent undue thickening at low temperatures, as wetting agents and as softeners in the manufacture of various plastics.

VERSATILE ORGANIC:

Isovaleraldehyde

Millmaster Chemical Co., 551 Fifth Ave., New York 17, N. Y., is now in commercial production of isovaleraldehyde, an organic chemical with many possibilities. For many years this aldehyde has been available only in pilot-plant quantities.

Isovaleraldehyde has a boiling point of 92.93 deg. C., a specific gravity of 0.785 and a normal density at 20 deg. C. of 1.390. It is slightly soluble in water and is miscible with organic solvents.

Possibilities abound for the new aldehyde in the manufacture of pharmaceuticals, synthetic resins and as a rubber accelerator. As a starting compound in organic synthesis, isovaleraldehyde has the isopropyl carbon chain with a reactive end group. It is suggested as a possible starting point for vitamin A synthesis.

Millmaster is producing the aldehyde at its Berkeley Heights, N. J., plant. Samples and complete information may be had by writing Millmaster at the New York address.

REACTIVE:

Potassium Cyanate

American Cyanamid Co., 30 Rockefeller Plaza, New York 20, N. Y., is now turning out semi-commercial quantities of potassium cyanate. This compound offers broad possibilities in chemical syntheses.

Potassium cyanate is a crystalline solid with a melting point of 310 deg. C. It is very soluble in water, giving a solution with a pH of about 9.2.

Reactions readily occur with such compounds as amines, alcohols, sulfonamides, acids, dialkyl sulphates, alkylene oxides and silicon tetrachloride. Products which may be prepared will find potential application in pharmaceuticals, surface active agents and agricultural chemicals.

Further technical data and samples are available from Cyanamid.

FOR DYESTUFFS:

Fluorine Hydrocarbon

Hooker Electrochemical Co., Niagara Falls, N. Y., is now producing in pilot-plant quantities a new fluorine-containing hydrocarbon. The product is 2-chloro-5-nitrobenzotrifluoride.

The compound is a straw-colored, thin, oily liquid, with a specific gravity at 25 deg. C. of 1.5520. Its freezing point is 16.8 deg. C. Its boiling point is 230 deg. C. Flash point of this new product is 135 deg. C.

This new hydrocarbon, containing fluorine, will be of particular interest in the preparation of dyestuffs and intermediates.

Technical Data Sheet No. 369 can be had from Hooker.

HIGH FLASH POINT:

Wax and Oil Solvent

Visco Products Co., Inc., City National Bank Bldg., Houston 2, Tex., is now supplying Visco VS, a new high-flash-point solvent for wax, grease, lube oils, paint and fusible or soft resins.

This solvent is non-injurious to skin, non-corrosive, and will not injure surfaces of metal or wood. Having a relatively high flash point, it is much safer to use than naphtha or other low-flash-point petroleum solvents.

As a cleaner, Visco VS may be safely used to remove oil-treating chemicals, wax, grease, lube oils, extreme-pressure lubricants and paint from skin, wood or metal surfaces. It may also be used as a general solvent where a slight blue discoloration would not be objectionable.

Visco VS is available immediately in 55-gal. drums and 5-gal. cans, direct from the plant at Sugarland, Tex.

HEAT AND LIGHT:

Stabilizers for Vinyls

Ferro Chemical Corp., Box 76, Bedford, Ohio, is now offering a new and complete line of heat and light stabilizers for polyvinyl chloride and associated copolymers. These stabilizers have been designed for ease of handling and incorporation in plastics processing. They impart excellent clarity and stability to clear stock at moderate cost. These stabilizers are equally effective in pigmented stocks and exhibit little or no reaction with pigments.

The efficiency of Ferro stabilizers has been thoroughly tested in numerous resin formulations using a wide variety of combinations and concentrations to obtain optimum ratios. For

(Continued)

Silicone News

DC SILICONES

DC 44 Silicone Grease Ends Bearing Failure in Textile Plant

Bearing failure may burn out your motors, stop your entire production line or ruin a mill run. That's why it's front page industrial news when the Plant Manager of a large textile plant reports that he has not had a single bearing failure since he started to use Dow Corning Silicone Oils and Greases over 30 months ago.

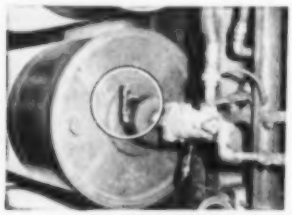


PHOTO COURTESY AMERICAN FINISHING COMPANY

DC 44 Silicone Grease in ball bearings on drying cans, operating at 400 r.p.m. around saturated steam journals, has 45 times the life of the organic grease previously used

Typical of the lubrication problems that plague plant engineers in textile plants is the maintenance of "steam-heated" bearings. It used to be necessary to lubricate bearings on drying cans and the main cylinder bearings of Sanforizing machines once every 8-hour shift. Since American Finishing started to use DC 44, the re-lubrication schedule has been cut to once every 30 to 45 shifts. The lubrication of Slashers on textile mills presented a similar problem that has been solved by using DC 44.

On tenter frame chains and races that travel through ovens at 400°F., petroleum oils carbonized so rapidly that the chains had to be cleaned periodically. That costly operation and the need for continuous lubrication have been eliminated by a weekly application of DC 710R Silicone Fluid.

American Finishing, like many other skillfully engineered companies, has found that Dow Corning Silicone lubricants more than pay for themselves in reduced maintenance costs. Increased production due to the virtual elimination of bearing failure is another one of the many bonuses Dow Corning Silicones pay to modern industry. For the most recent data on DC Silicone Greases phone our nearest branch office or write for data sheet No. D50.

DOW CORNING CORPORATION
MIDLAND, MICHIGAN

Atlanta • Chicago • Cleveland • Dallas
New York • Los Angeles
In Canada: Fiberglas Canada, Ltd., Toronto
In England: Albright and Wilson, Ltd., London

Dow Corning

FIRST IN SILICONES

New Products, cont. . .

both polyvinyl chloride and vinyl chloride-vinyl acetate copolymers, optimum stabilizer concentrations have been determined.

In addition to hundreds of tests made by Ferro Laboratories, many resin processors have tested Ferro stabilizers and are now using them successfully in production.

Those manufacturers of stock containing aluminum pigments will be interested to know that Ferro stabilizers No. 121 and No. 221 have no adverse effects on the leafing properties of the pigments.

Technical data, samples and other details can be obtained from Ferro Chemical Corp.

CHEMICALLY INERT:

Plastic Lining

Poly-Cyclo Products Co., Cleveland, Ohio, announces Cycloflex PC-11 plastic lining as a rugged chemically inert membrane developed specifically for the protection of drums and tanks.

Cycloflex is sturdy and tough, providing top resistance to corrosion and chemical attack. Inorganic acids, alkalis, aliphatic hydrocarbons, water, oils, grease, oxidants, cleaners and even the higher oxidizing reagents such as nitric and chromic acids are readily repelled.

Progress of work may be easily observed and tools, parts and other foreign matter accidentally dropped into tank or drums are easily detected with Cycloflex white inter-lining that permits solution visibility. This white lining is entirely non-contaminating to any plating solution including rhodium and gold. Drums and tanks lined with Cycloflex white have a smooth high-gloss finish that makes them easy to drain and easy to clean.

Cycloflex is also available in high-gloss black and like Cycloflex white, anneals to perfect homogeneity. Both linings withstand great fluctuations in temperature and will not break, crack, chip or peel even at high temperatures. High bond strength, superior density and seamless construction eliminate all possibilities of porosity and spot corrosion. "On the job" tests prove that Cycloflex offers more than any other lining in its price range, according to the manufacturers. It has an unusually long life, withstanding the severest mechanical abuse and being impervious to oxidation and deterioration.

Inside and outside bottoms of tanks and drums have an extra heavy coating of Cycloflex to assure greater protection and provide a cushion for increased safety.

Cycloflex-lined drums and tanks afford economical protection against corrosion.

This new plastic lining is being marketed nationally through Munray Products, Inc., Cleveland, Ohio, sales division of the Poly-Cyclo Products Co.

FOR EXTRUSION:

Tough Thermoplastic

Shawinigan Products Corp., 350 Fifth Ave., New York 1, N. Y., is now supplying Formvar, polyvinyl formal, the toughest of the thermoplastic resins, in extrusion grade. Its tensile strength is 12,000 psi. at 20 deg. C., which is higher than that of some of the newer plastics many times its cost. Because of this inherent toughness, it has until now been applied only from solution, but new extrusion equipment and techniques make possible the production of tubes, rods and sheets.

Formvar has excellent warp resistance, abrasion resistance and a high heat distortion point. It is completely resistant to oils, gasoline, aliphatic hydrocarbons, fats and waxes. It is also resistant to alkalis. These characteristics make it attractive for automotive parts, machine parts, gasoline and oil lines, as well as many other industrial uses.

ONE STEP FURTHER:

Cyclopentane Derivatives

Arapahoe Chemicals, Inc., 2800 Pearl St., Boulder, Colo., has extended its line of cyclopentane derivatives to include cyclopentanol and cyclopentyl bromide in addition to cyclopentanone and its oxime.

Since it was introduced first by Arapahoe in 1947, cyclopentanone has attracted considerable interest in the pharmaceutical and perfume industries as an intermediate. The introduction of the new derivatives responds to a demand for "one step further" in a number of synthetic processes.

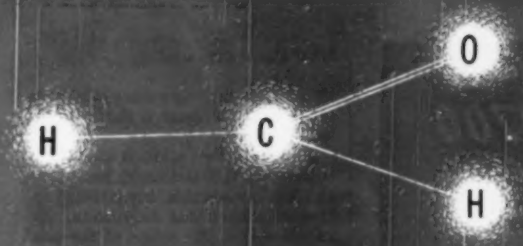
These compounds are available from stock in carboy lots, and drum lots can be made to order. Technical data and references describing these compounds and their uses may be obtained from Arapahoe.

FOR TRIVALENT IRON:

Sequestering Agent

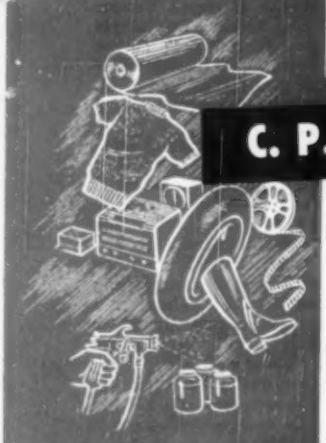
Bersworth Chemical Co., Framingham, Mass., has developed a new sequestering agent called Versene Fe-3. This is effective in withdrawing the trivalent iron that often exists as a chemical contaminant in solutions. Sequestering power of Versene Fe-3

(Continued)



HEYDEN FORMALDEHYDE

C. P. Quality in Tank Car Quantities



Purity of raw materials—whether in laboratory or plant—is the surest way to high quality products. Heyden Formaldehyde has for years been recognized as a standard of highest purity and uniformity in the manufacture of many diversified products—urea resins and textile chemicals—protective coatings and embalming fluids. Wherever C.P. quality may make the difference between "excellent" and just "satisfactory," Heyden Formaldehyde is the logical choice.

In tank cars or in bottles, Heyden Formaldehyde is a clear, colorless solution free of impurities which might cause residual foreign odor or discoloration. Produced under rigid laboratory control from C.P. raw materials, it assures uniform yields and high quality. Available as Formaldehyde Solution U.S.P. or as Methanol-free Formaldehyde, it assays not less than 37% by weight.

Shipped in tank cars, tank trucks, drums, carboys and bottles.

FORMALDEHYDE · PARAFORMALDEHYDE
HEXAMETHYLENETETRAMINE

Technical bulletins on the use and handling of Formaldehyde and its derivatives will be mailed promptly upon request on company letterhead.

Serving Industry through Finer Chemicals

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CHEMICAL CORPORATION
393 SEVENTH AVENUE · NEW YORK 1, N. Y.

FINE HEYDEN CHEMICALS

Benzaldehyde • Benzoates • Benzoic Acid • Benzyl Chloride • Bromides
Chlorinated Aromatics • Chlorobenzenes • Creosotes • Formates
Formaldehyde • Formic Acid • Glycerophosphates • Guaiacols
Hexamethylenetetramine • M. D. A. (Methylene Disalicylic Acid)
Paraformaldehyde • Parahydroxybenzoates • Penicillin
Pentaerythritols • Salicylates • Salicylic Acid • Streptomycin

CHICAGO 6: 20 North Wacker Drive • PHILADELPHIA 3: 1700 Walnut St. • SAN FRANCISCO 11: 420 Market St. • RUMFORD DIVISION: Rumford 16, R. I.

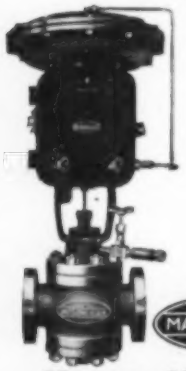
Here's the Pressure Controller You've Been Waiting for...

The Masoneilan No. 2700

- Liberal Use of Corrosion Resistant Materials
- Easy and Readily Accessible Adjustments

Look at these Features

1. Pneumatic proportionality accomplished with feed-back bellows and cantilever leaf spring.
2. Direct nozzle and flapper pilot with metering restriction.
3. Large powerful bourdon tube for greater response and control performance.
4. Wide selection of pressure ranges.
5. Cases for valve or wall mounting; also flush panel mounting.
6. Ease and accessibility of adjustments.
7. When steel construction is specified, controlled pressure connection, tubing to bourdon tube and entire bourdon tube assembly, are supplied with Type 316 Stainless Steel, in order to avoid corrosive effects.
8. Unit construction (proportional mechanism, nozzle block, etc.) and manifold.
9. Control action reversible with either bourdon or bellows.
10. Manifold construction prevents transmission of any possible case distortion to control mechanism.
11. Set point indication.



These controllers are designed for many industrial applications requiring accurate control where more expensive instruments are not warranted.

Applications include, among many others, pump governors, steam pressure reducing stations, gas well pressure reduction, etc., requiring small to intermediate proportional band.

The case is rugged and suitable for outdoor service; it is so designed that it may be mounted on the valve (on integral pad or by means of a U-clamp) or, *if the occasion arises, it may be removed from the valve and mounted on a wall.* A flush type case is also available for panel mounting.

MASONEILAN

Mason-Neilan Regulator Company

1197 ADAMS STREET, BOSTON 24, MASS., U. S. A.

Sales Offices or Distributors in the Following Cities: New York • Syracuse • Chicago • St. Louis Philadelphia • Houston • Denver • Pittsburgh • Cleveland • Cincinnati • Tulsa • Atlanta Los Angeles • San Francisco • Salt Lake City • El Paso • Boise • Albuquerque Mason-Neilan Regulator Co., Ltd., Montreal and Toronto

for calcium or magnesium at a high pH is almost as great as that of regular Versene.

A Versene Fe-3 solution containing sequestered (i.e. non-ionic) ferric iron also has considerable sequestering action on calcium and magnesium. As an example of the action of the new product, 10 cc. of Versene Fe-3 sequesters 167 mg. of ferric iron as well as 158 mg. of calcium at a pH of 7.

The action of both Versene and Versene Fe-3 varies with the pH of the solution. Versene Fe-3 is about twice as effective as regular Versene in sequestering trivalent iron at pH 12 and is about three times as effective at pH 7. Versene Fe-3 is only slightly less effective than regular Versene in sequestering calcium, magnesium and other alkaline-earth ions.

Trivalent iron in water and other aqueous solutions has always caused trouble in the preparation of soaps, fats, oils, emulsions, sanitizing agents, drugs, food products, textiles and metals. Until the discovery of Versene F-3, there has never been any good segregating or combining agent capable of overcoming it. Therefore, it should prove of intense interest to manufacturing and experimental chemists. Versene Fe-3 is now being produced in increasing quantities.

FOR PRINTING INKS:

Polyamine Resin Vehicle

Hilton-Davis Chemical Co., Langdon Farm Rd., Cincinnati, Ohio, has developed a new vehicle used for improving printing inks and varnishes. The new vehicle is a polyamine resinous composition.

Inks formulated with acidic resins react to the polyamine substances to make salt resin compositions that provide improved pigment wetting properties, better viscous stability and may be so compounded as to have better solubility characteristics than the acidic resin compositions.

This new development will help users of printing inks to cut costs. Without the new vehicle, inks tended to corrode equipment and to thicken and become heavy in body and eventually even to coagulate into heavy liver-like masses.

The improved pigment wetting, body and flow, strength of film, tone and like characteristics may be obtained in any type acidic resin containing coating or printing ink with the new invention. These include drying oil type inks and varnishes modified with polybasic acid resins; rotogravure type varnishes and inks con-

(Continued)

Important FACTS ABOUT pH for PROFIT-MINDED EXECUTIVES

WHETHER you are an executive responsible for planning long-range plant production, or for obtaining maximum efficiency from present processing operations, one of the most important advancements you can make is the installation of BECKMAN pH CONTROL. Through the proper application of modern pH control you can make many vital savings . . . savings that will quickly pay for the installation and will *continue* paying big dividends throughout the years. For example, some of the many benefits resulting from Beckman pH Control include . . .

. . . saving valuable chemicals through more accurate control of dosages.
. . . reducing costly corrosion by pre-regulating acid and alkaline solutions.
. . . speeding up process operations by operating at optimum pH values.
. . . minimizing rejects by increasing the uniformity of process solutions.
. . . *and many other important savings in time, materials and plant operating costs.*

▶ BUT TO MAKE CERTAIN you get the latest, most convenient and most accurate pH equipment available, be sure to specify "BECKMAN"...

Beckman pH equipment is completely electrometric, eliminating the mess and inaccuracies of colorimetric methods. Simply press a button and the exact pH of any process is instantly shown on a large easily-read dial. *It is the simplest of all pH methods!*

The accuracy of Beckman pH readings is completely unaffected by human errors in color judgment, by turbidity, oxidizing or reducing agents, by suspended materials, colored process solutions or other variables that affect outmoded colorimetric methods. *Beckman pH readings are universally accurate and dependable!*

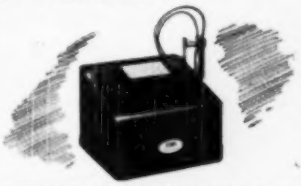
With Beckman equipment no time-wasting or troublesome sampling devices are needed. Beckman pH electrodes may be installed directly in vats, tanks, channels or flow lines—and exact pH values read instantly—and continuously, if desired—on the process fluids themselves.

Unique rugged-type Beckman Electrodes, specially designed for direct immersion in abrasive or suspension-laden fluids, reduce maintenance to an absolute minimum. *Beckman is the most trouble-free of all pH equipment!*

The above are only a few of many Beckman advantages. Beckman pioneered the modern glass electrode pH instrument . . . pioneered the first completely automatic pH indicator, recorder and controller . . . pioneered High Temperature Glass Electrodes which can be used continuously at temperatures as high as 212° F. (100° C.) . . . pioneered High pH Electrodes which permit accurate measurements of high pH values even in the presence of sodium ions . . . and pioneered many other vital advancements. IN FACT, Beckman is the only pH equipment embodying every modern advancement in the field of pH!

THERE'S A BECKMAN pH INSTRUMENT FOR EVERY NEED

COMPLETELY AUTOMATIC! The Beckman Model R instrument operates directly from standard 110 v. A.C. lines to provide completely automatic pH indication. Also provides for completely automatic pH recording and automatic process control. Can be installed to give accurate pH readings from various stations in plant through one instrument. *This is the pH unit being installed by today's most modern plants, large and small.*



PORTABLE A.C. OPERATION! The Beckman Model H instrument can be quickly moved from one part of the plant to another and plugs directly into standard 110 v. 50/60 cycle A.C. current. Compact, convenient and extremely simple to operate, the Model H gives instant pH readings on an easily-read dial. It is widely used both for manual pH control of small plants and as an auxiliary instrument on completely automatic pH installations.

COMPLETELY SELF-CONTAINED! The Beckman Model M is the ideal pH instrument where complete portability is desired. Operating from its own self-contained, long-life power supply, the Model M can be used anywhere in the plant or field, whether convenient to power lines or not. Features the same accuracy, simplicity and operating speed as the Model H, and is also widely used both for manual pH control of small plants and as auxiliary equipment on large automatic installations.

Write for literature on Beckman pH Equipment!

BRING YOUR pH PROBLEM TO US. Our trained engineers will gladly study your problem and recommend the equipment best suited to your particular requirements. No obligation, of course.

BECKMAN INSTRUMENTS
National Technical Laboratories • South Pasadena 14, California

BECKMAN

INSTRUMENTS CONTROL MODERN INDUSTRIES

Awarded by The Franklin Institute for Discovery, Invention or Development in Physical Science

JOHN PRICE WETHERILL MEDAL 1926

RESEARCH REPORT

NUMBER TWO

ON THE PROGRESS OF MAKING DRY SEPARATIONS BY SPECIFIC GRAVITY THROUGH AIR-FLOTATION

COMPILED FROM SIXTY-ONE YEARS OF SPECIALIZED EXPERIENCE IN SEPARATIONS

Problem: *Grading Coffee Beans*

Solution: *S S & S Process*

The following unretouched photographs illustrate graphically the efficiency with which a Model BX-100 Specific Gravity Separator was used to effect *a general grading by differences in the apparent bulk density of the various components.*

While this particular application of Sutton, Steele, and Steele separating equipment is standard plant procedure among coffee wholesalers and processors, it serves to emphasize how hundreds of other types of dry agricultural and industrial products can be salvaged from contaminations and unuseable materials, and up-graded to premium quality products.

PRODUCT No. 1, the heaviest material (lbs. per cubic foot), consisted of top-grade coffee beans and represented 22.2% of the total volume. Note the consistency in general appearance of each individual bean.

PRODUCT No. 3, consisting of lower grade beans of medium weight, is an arbitrary gradation made to control the quality of Product No. 1. After Product No. 1 has been salvaged, Products No. 2, No. 3, and No. 4 can then be re-graded in the identical manner.*

PRODUCT No. 5, containing hulls and broken beans, was removed at the lower, or "lighter," end of the deck and represented 7.5% of the total volume. Check YOUR separating problem today. Chances are, the S S & S Process is your answer, too.

*Products No. 2 and No. 4, also of middle grades, have not been shown due to space restriction.

LITERATURE AVAILABLE

Tell us about your separating problem and we will forward bulletins which describe in detail how the famous S S & S Process can be applied successfully to your particular needs. Address inquiries to:

DEPARTMENT C
SUTTON, STEELE & STEELE, INC.
1031 SOUTH HASKELL AVENUE
DALLAS, TEXAS, U.S.A.

SUTTON, STEELE & STEELE, INC.

Dallas, Chicago, Des Moines, Minneapolis, New York City, Pittsburgh, San Francisco, Columbus, Ga., Jackson, Mich. Foreign: Winnipeg, Canada; San Paulo, Brazil; London, England.

taining a solution of polybasic acid; and heat-set type inks that are acidic.

Some of Hilton-Davis' flushed colors are now being flushed with the new patented vehicle.

TO TAG AMINES:

Analytical Reagent

Arapahoe Chemicals, Inc., 2800 Pearl St., Boulder, Colo., has added to its line of unusual analytical reagents 2,4-dinitrobenzaldehyde, a reagent for characterizing amines and certain compounds which contain active hydrogen. Although the reagent has been known for 20 years and a large number of amines and methyl heterocycles have been characterized, the reagent has only recently been offered commercially.

It is claimed that in addition to its use as an analytical reagent the compound has much promise in the field of synthetic chemistry.

The 2,4-dinitrobenzaldehyde can be had from stock in research quantities. Technical data describing this compound may be had on request.

FOR PAPER MAKERS:

Wet-Strength Resin

Resinous Products Division of Rohm & Haas Co., Philadelphia, Pa., is now producing commercially a new wet-strength resin for the paper industry. This resin is said to be unique in its stability and its adaptability to a wide range of paper products.

This urea-formaldehyde resin is Uformite 520, one of the family of Uformite resins produced by the Resinous Products Division of Rohm & Haas Co. The new resin is identical with the liquid Uformite 467, except that it is supplied in powder form. Its useful life of a year or longer becomes important in mills where runs of wet strength paper are sporadic or where storage and handling of liquid resins in the plant may be impractical. Like its liquid counterpart, it is designed to improve the retention of rosin size and other beater additives, to impart better fold as well as increased pick resistance to printing papers, and to increase economically the wet-rub resistance of starch-clay coatings.

The Uformite 520, which is completely soluble in water and gives solutions water-clear in appearance, may be added directly to the beater, fan pump, stuff chest, head box, or at other points on the wet end of the paper machine, where adequate agitation insures dispersion of the resin in the stock. Solids content of the solution is not critical.

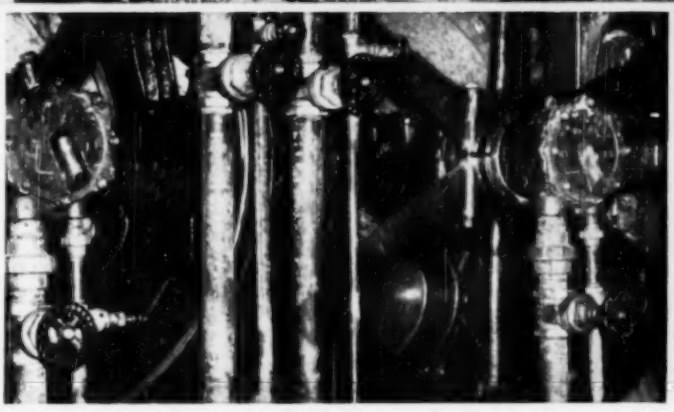
(*Continued*)

OIC VALVES
SLASH MAINTENANCE COSTS FOR SONOCO PRODUCTS CO.

In the Hartsville, S. C., plant of Sonoco Products Co., OIC Valves play an important part in the manufacture of such paper specialties as textile cones, mailing tubes, drug cans, electrical tubes, fuse tubes, spools and paper mill cores.

•

Most of the small valves shown here on a Sonoco paper machine are 2-inch size. Other OIC *Valves, in a wide variety of trims and sizes, are used on lines for such varied services as Paper Stock, Paste, Steam Power, Process Steam, Compressed Air, Water, Fuel Oil and Air Conditioning Equipment.*



SONOCO, one of the nation's leading manufacturers of paper specialties, has learned that OIC Valves cost less, over the years, than any other valves. Sonoco's own long-kept maintenance records furnish the proof!

Reasons? Plenty!

OIC Valves feature heavier construction to control pressures and stresses safely! Their streamlined design protects the flow from turbulence. Leakproof joints guard against pressure drop. Wedges of heavy I-Beam design control the flow with positive action. Integral body ribs are precision-designed — effectively reduce vibration and wear.

All these and many more outstanding features tell why Sonoco and hundreds of other leading valve users find OIC the "Pace-Setter in Valves"!

SEND FOR YOUR FREE COPY OF OIC'S VALUABLE VALVE CROSS REFERENCE CHART

Easy to use — saves you time and money! Simply check the number of the valve you wish to replace, look in the chart, and you'll find the right OIC valve. Write to The Ohio Injector Co., Wadsworth, Ohio for your free copy.

D-349-15

OIC

SETS THE PACE IN VALVES

STEEL • IRON • BRONZE

KNOWN THE WORLD OVER AS A SYMBOL OF RUGGED RELIABILITY IN HIGH PRESSURE COMPRESSORS

In far distant places where high pressure is required you will find Norwalk Compressors at work, thousands of miles from home. That's where dependability counts. The same reliability saves dollars in your plant, year after year. For best results, get an estimate on a Norwalk suited to your specific requirements.

Norwalk Company, Inc.

South Norwalk, Connecticut

but should be 10 percent or lower to insure good mixing with the pulp. Temperature of the dilution water should be at least 50 deg. F. As with Uformite 467, alum is specific for use with the new resin. Normal procedure requires the use of sufficient alum to reduce the pH of the stock to 4.0-4.9.

Also like the 467 formulation, Uformite 520 does not develop its full wet strength immediately off the machine; a natural aging period of from one to two weeks at 75 deg. F. is required. Consequently, broke recovery is accomplished readily without special precautions. Fresh broke may be returned directly to the beater while aged broke can be defibered readily by raising the temperature in the beater to 140-160 deg. F. and adjusting the pH of the stock to 4.0-4.9 with alum or acid. Under such conditions, fully aged broke can be repulped in a matter of minutes.

Besides imparting wet strength, Uformite 520 acts effectively in improving the retention of rosin size and other beater additives. As little as 0.5 percent resin will greatly improve sizing efficiency of rosin. Improvements in the pick resistance of several numbers on the Dennison scale can be obtained in printing papers. When used to improve the wet rub of starch-clay coatings, from 10 to 20 percent resin solids, based on starch solids, will provide wet-rub resistance equal to that obtained with casein formulations.

VITREOUS:

Enamels for Aluminum

E. I. du Pont de Nemours & Co., Inc., Wilmington 98, Del., now has enamels for certain alloys of aluminum ready for large-scale evaluation by the aluminum and enameling industries. It took six years of research by the Electrochemicals Department of Du Pont to produce these enamels for aluminum.

The new enamel for aluminum is vitreous. It is fired on aluminum strips, sheets and castings in furnaces like those used to apply porcelain to steel.

Research at the present time has developed satisfactory enamels for two alloys of aluminum, 61-S wrought alloy and 43 casting alloy. Test panels exposed for two or three years on the roof of a large city building indicate the probability that the enamels will be satisfactory on certain other alloys. However, Du Pont is recommending the enamels for use on only the two alloys for the present.

The new enamels for aluminum contain a high percentage of lead, making them unsatisfactory for coating articles

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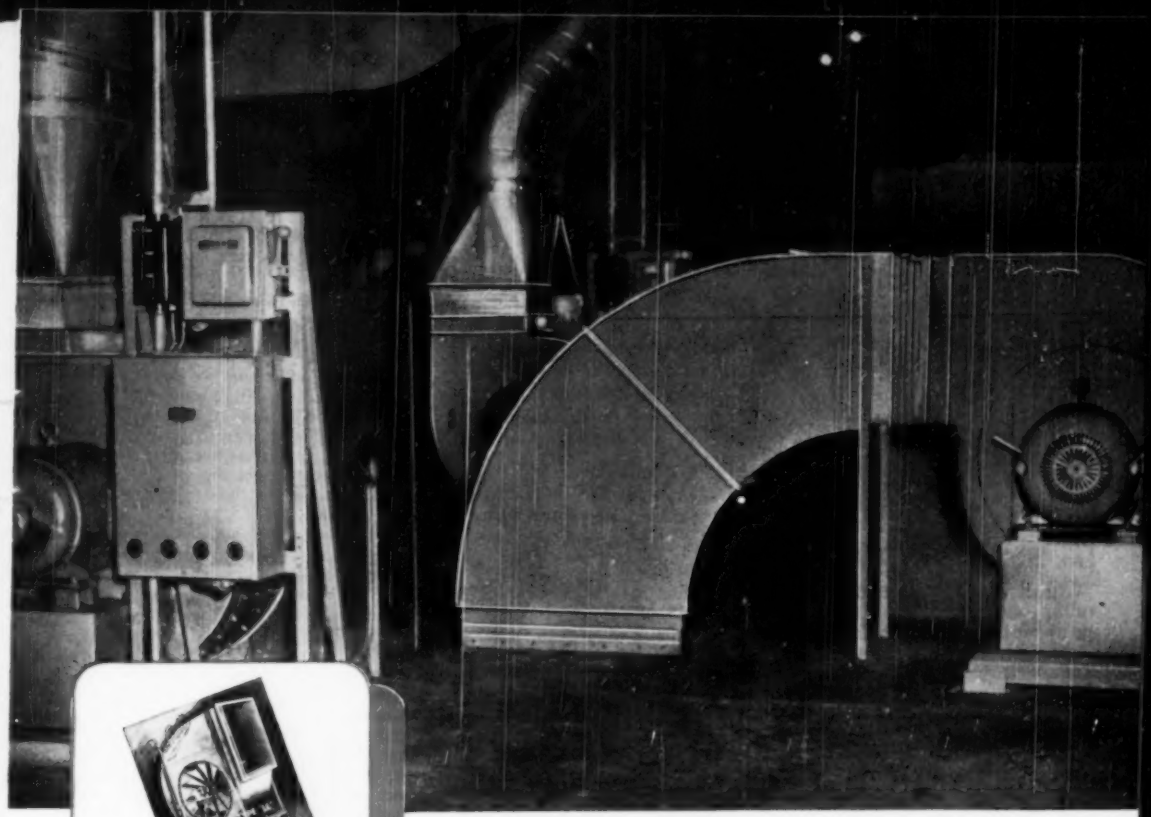

FREE FACTS!

Yours for the writing, Bulletin 3675, above, gives all engineering data on "Buffalo" Limit-Load Fans. Shows the remarkable range of sizes and arrangements to suit your particular application for low-cost air. Write now!

Supplying FAR MORE *Than* ECONOMICAL FRESH AIR

What is dependable air moving service worth to YOUR PLANT? A great deal, when it means adequate fresh air that makes employees more productive—when it means thorough fume or moisture removal for better quality control and increased plant safety! It can mean A BETTER PRODUCT AND MORE OF IT!

"Buffalo" Limit-Load Fans can give YOU these very real benefits. They are doing it for thousands of chemical and processing plants. And they are doing it to complete satisfaction in on-the-job performance and "cost per CFM". Here's quiet, smooth, TROUBLE-FREE air service! Specially shaped housings, scroll and double curved blades—dynamic wheel balance—slow speed operation—all mean "extra" performance that pays for itself year after year. "LL" fans are non-overloading, and may be had in almost the exact size you need—assurance of ENOUGH air at the lowest possible power cost. Why not let your trained "Buffalo" representative show you the EFFICIENCY jobs these fan can do for you?

A "Must" For Every Engineer!

FAN ENGINEERING, 5th Edition, gives you a wealth of practical straight-to-the-point answers on practically every air problem. Pocket size. Result of 70 years of fan experience. *Order now!*

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EXTRA HERE'S NEWS EXTRA

THE SUPERIOR ELECTRIC COMPANY, BRISTOL, CONNECTICUT

ANOTHER NEW TYPE IE HAS BEEN ADDED TO THE FAMILY OF STABILINE VOLTAGE REGULATORS

THE NEW 500VA STABILINE TYPE IE51005

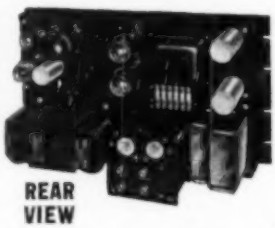
A new 500VA voltage regulator, delivering a constant output voltage regardless of variations in input voltage or load current. "Type IE" indicates this STABILINE is Instantaneous Electronic. This means completely electronic operation — no moving parts to get out of order and it gives the fast speed of correction available only when no moving parts are involved. STABILINE Type IE51005 is available as a cabinet model or for rack mounting. It has the same superior characteristics as other STABILINES well-known in the electrical industry for their quality of workmanship and performance.

All the tubes, but one, are standard — this one made to Superior Electric specifications by a well-known manufacturer and easy to order when replacement is necessary. The 500VA STABILINE Type IE51005 is easy to order, too. No suffixes to confuse you — no "extras" or "special designs" to increase the cost. STABILINE *standard* models give you the performance of other "specials".

Complete information on the Type IE51005 and other STABILINES of various ratings and capacities is available upon request.

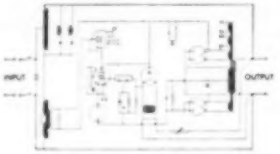
RATINGS

Input Voltage Range: 95 to 135 volts. **Output Voltage Range:** Adjustable between 110 and 120 volts. **Rated Output:** 0-500 volt-amperes. **Frequency in Cycles:** 60 ± 10%. **Load Power Factor Range:** 0.5 lagging to 0.9 leading. **Waveform Distortion:** *never* exceeds 3%. **Stabilization:** ± 0.1 of 1% of the preset value. **Regulation:** ± 0.15 of 1% of the preset value. **Recovery Time:** 3 to 6 cycles.



REAR VIEW

Here's compact, well-organized construction of IE51005, built to give long, trouble-free service.



CIRCUIT DIAGRAM

Operating circuit and components of the new 500VA STABILINE.

WRITE US TODAY. 2059 MEADOW ST., BRISTOL, CONN.

THE SUPERIOR ELECTRIC CO.
BRISTOL, CONNECTICUT

POWERSTAT VARIABLE TRANSFORMERS • VOLTBOX A-C POWER SUPPLIES • STABILINE VOLTAGE REGULATORS

that are likely to come into contact with food. Tests have shown that the resistance of the enamels to acids and alkalis is comparable to that of enamel on steel.

Equipment for applying the new enamels to aluminum is substantially the same as that for enameling steel. However, the aluminum enamels are fired at a temperature several hundred degrees below that employed in enameling steel, a fact which effects economies in the initial cost and in operation of furnaces.

Enameled aluminum is unusually mar-resistant, but if it is accidentally chipped or cracked the aluminum will not develop unsightly rust. Enameled aluminum sheets for architectural purposes can be made in any convenient standard length, shipped to the job, sawed and fit.

Enameling of aluminum to increase its resistance to corrosion and widen its decorative uses, will broaden its usefulness, particularly outdoors where it is subject to weather and the corrosive effects of the atmosphere. Enameled aluminum already is being used for store-front panels and for advertising display letters. Vitreous enameled aluminum sanitary ware and accessories, washing-machine tubs and agitators, architectural tile and outdoor furniture are among the more immediate prospects for evaluation, according to Du Pont.

With production of the enamels on a small scale at present, the cost of enameling aluminum is somewhat higher than the application of porcelain on steel.

BINDS FOUNDRY CORES:

Thermosetting Resin

American Cyanamid Co., 30 Rockefeller Plaza, New York 20, N. Y., through its Plastics Dept., has recently introduced a new synthetic resin developed for the binding of sand cores. This new resin is the result of extensive research on foundry problems and will be marketed under the trade name of Cycor 151.

It is a neat, thermosetting resin made under carefully controlled conditions and especially prepared as a water-resistant foundry core binder. It contains no filler nor additives of any kind. The foundry may vary the amount of Cycor 151 or other additives to obtain cores with green and baked tensiles, permeability, hardness and collapsibility necessary for the type casting to be made. Its use also makes possible cleaner, more uniform castings.

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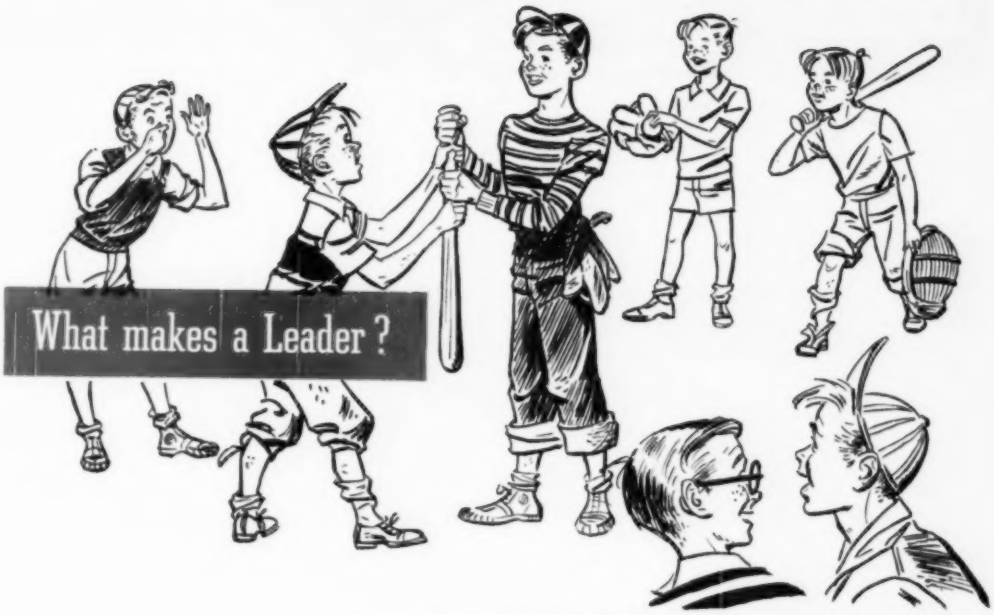

Leaders don't just happen. In most cases, it is the combination of skill, performance and facilities that add up to make one "the leader."

The unsurpassed quality and uniformity of Solvay products are backed by:

- the facilities of five strategically located plants
- the long experience and production skill of the men who run these plants
- a progressive research organization working with the finest in laboratory equipment
- Solvay's "Industry-Wise" Technical Service which serves you with an intimate knowledge of your industry, and offers expert advice on the use, handling, and storing of alkalies
- prompt and convenient delivery from more than two hundred local stock points covering the entire country

This combination of services, offered by America's first and largest manufacturer of alkalies and associated chemicals, clearly establishes Solvay as the leading producer in the field.

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Ammonium Bicarbonate • Sodium Nitrite • Para-dichlorobenzene
Ortho-dichlorobenzene • Monochlorobenzene • Methanol
Ammonium Chloride • Formaldehyde

B.T.U. *digest*

THROWING LIGHT ON HEAT TRANSFER PROBLEMS

Prepared by

THE WHITLOCK MANUFACTURING COMPANY

Main Office and Plant, 94 South St., Elmwood, Hartford 2, Conn.

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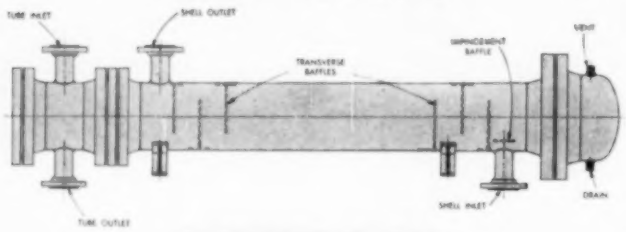

WHITLOCK
STANDARDIZES FOR ECONOMY

As an example of Whitlock Standardization the construction of the ST Heat Exchanger will be of interest. A good bit of our engineering effort has been devoted to standardization for the purpose of avoiding costly "specials" wherever possible. One of the results of this program is illustrated by the wide range of Standard Type ST Heat Exchangers now available. The Whitlock Type ST is a straight-tube floating head (split ring design) exchanger. Units are available in 150# and 300# design pressures and can be furnished of all-steel construction or with steel shell and nonferrous tube bundle construction, replacing many special, more costly units.

Today the reduction of manufacturing costs is of vital concern to all manufacturers, and standardization—whether partial or full—is a big step in the direction of economy. Standardization helps reduce engineering costs, and also permits quantity purchasing—resulting in reduced material costs. Partial or whole pre-fabrication of major subassemblies, even with heavyweight heat exchangers, likewise means lower production costs. Standardization of the Whitlock ST Heat Exchanger now allows the application of low cost standard units to special and individual operating conditions, and greatly expedites deliveries. This is very important to the customer since single units, series of units, and replacement parts as well, are available for early shipment.

APPLICATIONS

The Whitlock Type ST Heat Exchanger of straight tube floating head design (split-ring assembly) has large scale application to the typical process heat transfer problem. Whether the service calls for heating, cooling or condensing and whether the process fluids have viscosity characteristics of a light fraction or of a heavy tar, the unit has application because of its fundamental consideration of thermal design details, mechanical characteristics and maintenance requirements.

WHITLOCK

DESIGNS and BUILDS Boards • Coils • Condensers • Coolers • Heat Exchangers Heaters • Piping • Pressure Vessels • Receivers • Reboilers

cores which withstand high humidity and long lay-overs in molds. It can be cured in either conventional or dielectric ovens and allows quick-cured cores for rush jobs. Because Cycor 151 is a pure resin, only small quantities are required. This saves the user money because he purchases only the neat synthetic resin, modifying it with fillers and extenders to meet his own special requirements. The short baking cycle required increases oven turnover and thus increases production per hour. Cycor 151 gives foundries 33 percent to 50 percent faster baking time than old-time binders at baking temperatures of only 350 deg. F. The excellent collapsibility insures savings in shake-out and cleaning.

Cyanamid has developed, produced and tested this new resin, and foundry people using Cycor 151 can call upon Cyanamid's technical service men for assistance in getting satisfactory results and economics.

BUGABOO FOR BUGS:

Neutral Calcium Arsenate

Pennsylvania Salt Mfg. Co., 1000 Widener Bldg., Philadelphia 7, Pa., has developed a new zero-lime calcium arsenate that may be successfully combined with organic insecticides for the control of virtually all cotton-infesting insects. To be marketed under the trade name Pencal, this special neutral calcium arsenate was developed at Pennsalt's plant in Bryan, Tex., for its Penco line of agricultural chemicals.

This new product was designed for combination with such organic aphicides and miticides as benzene hexachloride, DDT and parathion, without the chemical breakdown of the organic ingredients, as occurs where regular calcium arsenate is used.

Thus, with one mixture, such cotton insects as boll weevil, leafworm and boll worm can be controlled without danger of developing infestations of aphids and red spider. To the cotton farmer, this means substantial savings in the cost of pest control.

Pencal alone is recommended by Pennsalt for control of boll weevil, leafworm and boll worm. Combined with benzene hexachloride, it also eliminates aphids and fleahoppers. By adding parathion or sulphur to this mixture, spiders, too, may be controlled.

Before being offered for sale, Pencal was subjected to both greenhouse and field tests by agricultural experimental station technologists in the South. All claims made for its effectiveness by Pennsalt were substantiated.

Pencal will be available for the cur-

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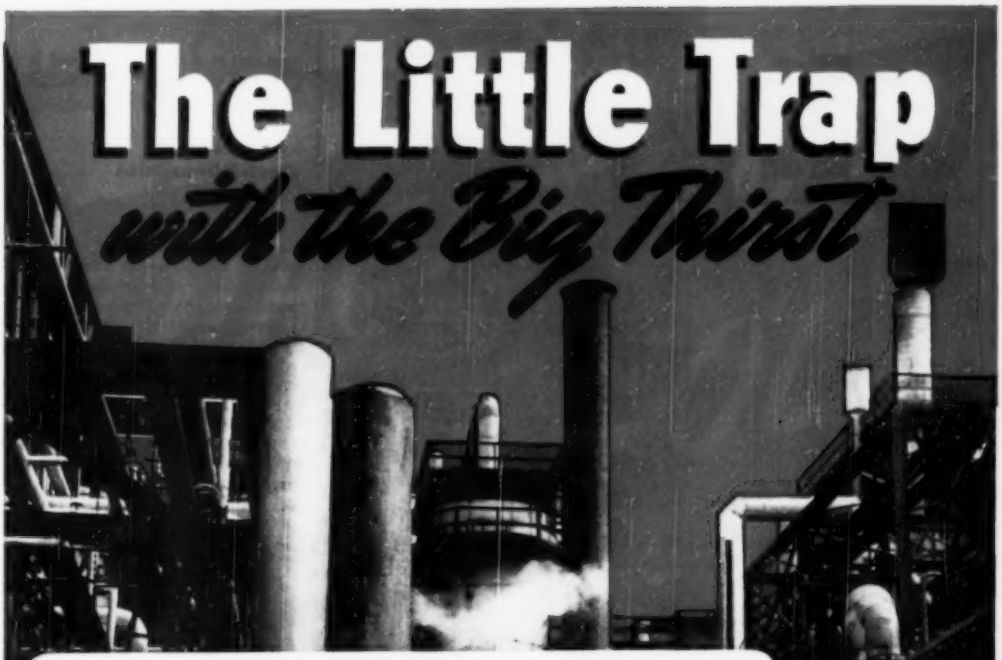
The Little Trap *with the Big Thirst*



Yarway Impulse Steam Traps—those little traps with the big thirst—are doing a giant's job for hundreds of plants in many industries throughout the country.

For instance, Yarways are ideally suited to refinery work because they literally *drink* the condensate—discharging continuously on heavy loads, intermittently on light loads. Hence they provide maximum heat in the shortest possible time.

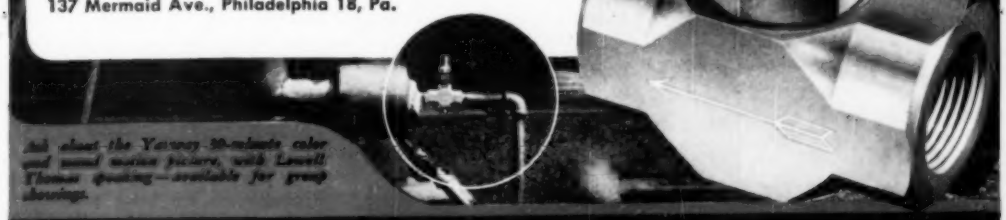
Yarways are all-weather traps, equally efficient outdoors or in—require no protection against freeze-up.

Yarways are suitable for all pressures without change of valve or seat. Compact design makes them easy to install, and simplicity of construction (only one moving part) minimizes maintenance.

Next time old-type traps need repair, consider replacing them with Yarway Impulse Traps. New Yarways frequently cost less than the repair job. *Already more than 600,000 have been bought!*

See your nearest Supply House, or write for Bulletin T-1739.

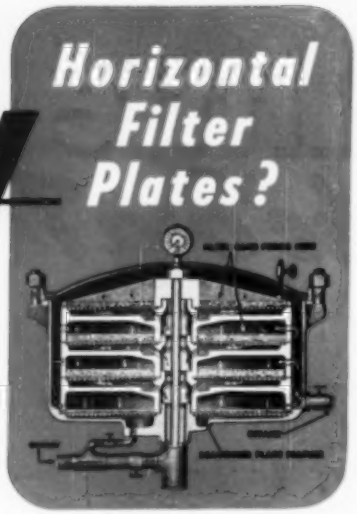
YARNALL-WARING COMPANY
137 Mermaid Ave., Philadelphia 18, Pa.



Ask about the Yarway 30-minute color and sound motion picture, with Lowell Thomas speaking—available for group showings.

YARWAY IMPULSE STEAM TRAP

why Horizontal Filter Plates?



because—with horizontal plates, filter aids are permitted to flow in a natural direction, with gravity, and are deposited in an even cake of uniform thickness.

because—the filter cake rests flat on the supporting plate without tensile or distortive strain, will not crack, slip, or break under pressure, assuring even filtration.

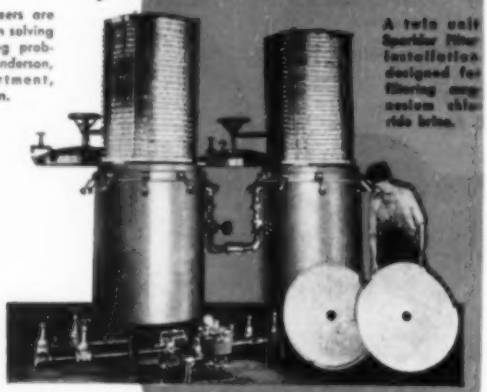
because—any filter paper, cloth, screens, or filter media can be used. Strength in the cake itself is not important, pressure simply presses the cake more firmly on the supporting horizontal plate.

because—horizontal plates are bolted together in a unit that is easily removed for cleaning. An extra unit assembly of horizontal plates can be immediately placed in the filter and the filtering process continued with slight interruption.

This is only part of the story—other exclusive features like the patented scavenger plate that makes possible the recovery of the last of a batch run and other operating advantages are reasons why Sparkler Horizontal Plate Filters are so widely used in the chemical processing industry.

SPARKLER *horizontal plate* **FILTERS**

Our filtration engineers are ready to cooperate in solving any of your filtering problems. Write E. S. Anderson, Industrial Department, for personal attention.



A twin unit Sparkler filter installation designed for filtering magnesium chloride brine.

SPARKLER Manufacturing Co., 320 Lake Street, Mundelein, Ill.

rent cotton-dusting season, and it will cost the same as the regular calcium arsenate.

ASPIRIN'S COUSIN:

Anti-Rheumatic

Monsanto Chemical Co., St. Louis, Mo., through its Organic Chemicals Division, is now supplying the pharmaceutical industry with chemicals that show promise in the treatment of rheumatic disorders. The new chemicals, however, as yet can be had only in limited quantities.

The products, commonly known as gentisic acid and sodium gentisate, are chemically related to aspirin. Gentisic acid, it is believed, may be the chemical produced by the body from sodium salicylate, which has long been used in the treatment of rheumatic disease.

One theory, based on preliminary studies, is that gentisic acid inhibits the action of an enzyme in the body. While enough data is not yet available to prove this theory, it is believed that the enzyme destroys the body's tissue cement, causing the pain, swelling and high temperatures typically associated with rheumatic diseases.

Monsanto cautions, however, that extensive work must be done by the pharmacologists and clinicians before the utility of the products is fully established. Gentisic acid and related products are being made available to the pharmaceutical industry for research on the broad scale necessary for such development.

COMMERCIALLY AVAILABLE:

Isopropyl Phenols

Koppers Co., Inc., Pittsburgh 19, Pa., is now offering commercial quantities of the isopropyl phenols. This step results from research conducted by the Chemical Division of Koppers. The isopropyl phenols, although new as commercially available compounds, have already found useful applications.

Isopropyl phenols are now produced in three grades: ortho-isopropyl phenol, a relatively pure ortho isomer; meta, para-isopropyl phenol, a close-boiling mixture of the meta and para isomers; and diisopropyl phenol, a mixture of the dialkylated phenols.

The compounds are produced in commercial quantities by Koppers at its plant at Oil City, Pa. Since these compounds are being produced by chemical synthesis rather than by refining of coal tar or byproduct materials, it is possible to expand their production many times. Their poten-

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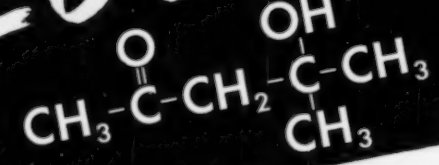
From SHELL CHEMICAL . . .

DIACETONE ALCOHOL



a high-boiling solvent for cellulose ester lacquers

● Diacetone Alcohol gives exceptional performance as a high-boiling solvent for cellulose acetate and cellulose acetate butyrate . . . is excellent for nitrocellulose. The presence of Diacetone Alcohol in *your* lacquer formulations will result in an improved product with these advantages:

Better film flow. Diacetone Alcohol is widely employed to control the evaporation rate of lacquers. A small quantity, in combination with active lacquer solvents, imparts improved flow properties to the final product.

Greater blush resistance. Diacetone Alcohol not only improves film flow, but it also eliminates blushing during the application and drying of the lacquer film. A superior film appearance is thus obtained.

Mild Odor. Diacetone Alcohol is particularly suitable for use in interior brushing lacquers, because of its faint but pleasant odor. This property, together with its slow evaporation rate, makes Diacetone Alcohol excellent for dipping and roller-coating applications.

Properties

Molecular Weight	116.16
Specific Gravity 20/4°C	0.9382
Boiling Point (760 mm)	166°C (approx.)
Freezing Point	—44°C
Refractive Index	1.4232
Vapor Pressure 20°C	0.84 mm Hg

Lacquer Solvent Properties

Dilution Ratio	
Toluene	3.0
Aromatic Naphtha	1.0
Aliphatic Naphtha	0.5
Viscosity 25°C (8% soln. ½ sec. nitrocellulose)	153 cps.
Blush Resistance (% relative humidity at 80°F)	87
Rate of Evaporation (n-butyl acetate = 1.0)	0.2

Other Applications. An effective solvent for penta-chlorophenol, the widely used wood fungicide . . . excellent in hydraulic fluids . . . an important ingredient of industrial dyes and stains.

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In handling liquids and semi-liquids, install ILLINOIS porcelain pipe and fittings for a permanent means of handling materials.

ILLINOIS PORCELAIN SYSTEMS FOR HANDLING LIQUIDS GIVE YOU THESE ADVANTAGES:

1. Smooth, corrosion-proof inside surfaces. No pitting or rough spots on pipe's inner walls.
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3. Illinois porcelain pipe prevents wet spots caused by condensation.

Write today for illustrated catalog =C-2, covering the ILLINOIS line of standard porcelain products. Types and sizes to meet your specific requirements. Your inquiries concerning special porcelain needs are welcome.

WITH ILLINOIS PORCELAIN PIPE LINES YOU GET . . .

★ ***Quality Control***
No changes in composition of material during its handling in the plant.

★ ***No Electrolitic Action***
Non-absorbent porcelain does not pick up minerals or metals in material being handled.

★ ***Production Cost Savings***
Corrosion-proof porcelain cuts maintenance. Spoilage in materials is reduced because porcelain is permanent.

CHEMICAL
ILLINOIS
ELECTRIC PORCELAIN CO.
MACOMB, ILLINOIS

tial availability in large quantities will make them valuable for many applications not open to the cresols and xylenols, the supply of which is limited by the amount of coal tar available to the coal tar refiners.

Properties and chemical reactivity of the isopropyl phenols are somewhat similar to those of the corresponding cresol isomers. The pure ortho isomer freezes at 15.8 deg. C. It boils at 214.1 deg. C. at 760 mm. Hg, and it boils at 122.0 deg. C. at 20 mm. Hg. It is completely soluble in 10 percent sodium hydroxide solution. The pure meta isomer freezes at 25.9 deg. C. It boils at 228.6 deg. C. at atmospheric pressure, and it boils at 127.0 deg. at 20 mm. Hg. It is also completely soluble in 10 percent sodium hydroxide solution. The pure para isomer has a freezing point of 63.2 deg. C. Its boiling point at 760 mm. Hg is 228.5 deg. C., and at 20 mm. Hg it boils at 127.0 deg. C. Like the other isomers it is completely soluble in 10 percent caustic.

Chemical reactivity of the isopropyl phenols is typical of the lower monoalkyl phenols. The phenolic hydroxyl group may undergo reactions such as esterification and etherification; the aromatic nucleus is subject to reactions such as halogenation, nitration, alkylation, aldehyde condensation and hydrogenation. Phosphate esters of the isopropyl phenols can be prepared by reaction with phosphorus oxychloride, and derivatives such as dinitro-ortho-isopropyl phenol can be prepared by reaction with nitric acid.

Although previously available to research workers only in limited quantities, the isopropyl phenols have already been found to have several promising uses. The alkyl phenols themselves are powerful high-boiling solvents which are valuable for certain wire-coating compositions and for use in engine cleaning formulations. The phosphate esters offer promise as plasticizers for vinyl resins and related materials. The dinitro derivative of the ortho isomer has definite value as a selective herbicide and insecticide, and offers the special advantage that the sodium salt is extremely soluble in water.

Other uses for which the isopropyl phenols are suggested include the preparation of lubricating oil additives, the manufacture of phenolic surface-coating resins and the production of rubber processing chemicals.

Samples of the several grades of the isopropyl phenols are now available to research and development chemists. Requests should be addressed to the Chemical Division, Koppers Co., Inc., Pittsburgh 19, Pa. —*End*

CUT HIGH OPERATING COSTS... DURING THE WARM MONTHS!

Get Low-Cost HOT WATER with CHROMALOX Electric Circulation Heaters

Efficient CHROMALOX *Electric* Heaters eliminate expensive coal or oil fired steam-boiler operation during the months boilers are not used for plant heating.

These easy-to-install Heaters connect to the water tank . . . or directly to water-utilizing equipment for "made-on-the-spot" hot water. Automatic or manual controls assure a plentiful and dependable supply at low cost.

CHROMALOX Circulation Heaters are also used for pre-heating cheaper fuel oils, heating oil-jacketed processing equipment and superheating steam. In fact, these and many other CHROMALOX *Electric* Heaters can do hundreds of heating jobs in your plant *more efficiently* and *at less cost.*

THESE ADVANTAGES ARE YOURS WITH CHROMALOX ELECTRIC HEAT

1. EFFICIENT heat when and where you need it.

2. ECONOMICAL initial cost, low operating and maintenance costs.

3. ACCURATE temperature control holds heat within desired limits, maintained thermostatically or manually.

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6. BETTER process, production and product—uniformly high in quality.

7. NATION-WIDE organization of Application Engineers to give you practical "on-the-job" assistance.

WANT MORE KNOW-HOW?

Send for Catalog No. 42 on CHROMALOX Electric Heaters; the useful booklet of application ideas "100 Ways to Apply Electric Heat", and the address of CHROMALOX Application Engineer serving you.

CHROMALOX

Electric Heat for Modern Industry

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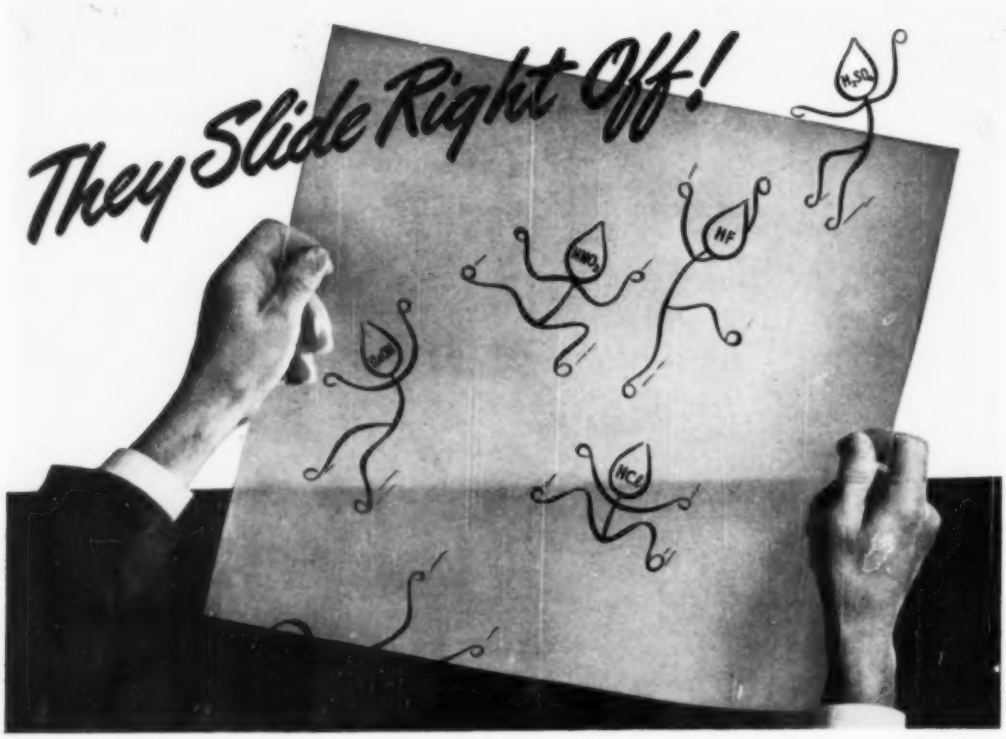

CORROSIVE CHEMICALS GET NO GRIP ON

DU PONT

For containers of all kinds . . . liners for metal or fibre drums, shatter-resistant bottles, cap liners, gaskets, and tubing . . . the outstanding chemical inertness of Du Pont polythene is one of its chief advantages. Men who handle corrosive chemicals are constantly finding new uses for this versatile Du Pont plastic. But chemical inertness is not the whole story . . . far from it.

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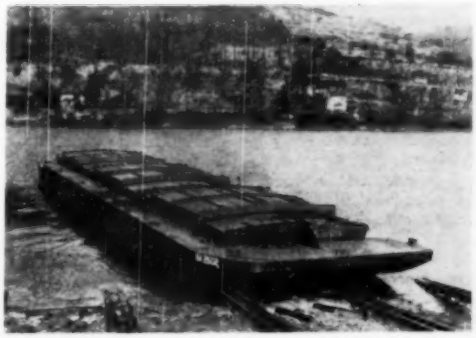
AT ROOM TEMPERATURES THERE IS NO KNOWN SOLVENT FOR DU PONT POLYTHENE

The Plastics Dept. of the Du Pont Company manufactures polythene molding powder. Extruders, molders and other processors supply polythene in the form of

Handling, Packaging and Shipping

R. W. LAHEY, Editorial Consultant



Special barges . . .

. . . and tanks help meet . . .

The Problems Posed by Increased Costs of Transportation

Increases in rail freight rates have been accompanied by higher transportation charges by motor carriers. In some instances, rates published by individual motor carriers have been suspended by action of motor carrier conferences when such rates are lower than conference rates. This principle of independent filings is now under attack before the ICC by motor carrier conferences.

Thus, the chemical shipper finding motor truck rates closely following the upward trend of rail rates is forced to find some means of offsetting these increases in transportation costs. Elimination of container costs by resorting to bulk shipments is limited to a small portion of the industry's business due to the large volume of shipments required to make the purchase of bulk handling equipment and bulk storage containers profitable. Mechanized methods of loading and unloading are receiving close scrutiny.

Unit loads on returnable or expendable pallets is thought by some to be a possible source of relief. Publicized so widely during and immediately after the war, shippers have misunderstood the obvious economic limitations of this method. A cost comparison of efficient carloading for palletized and unpalletized shipments will show that the labor savings for palletized shipments will be far less than the cost of even the cheapest expendable pallets. Return charges for returnable pallets (weight approximately 100 lb. for 48 x 48-in. size) and low dunnage allowances by railroads make the cost of their use prohibitive.

The recently announced and widely publicized proposal for construction of a 130-mile conveyor belt between Lake Erie and the Pittsburgh district will provide a means of reducing transportation costs of coal, iron ore, and limestone between East Liverpool and Lorain, Ohio. With two-way operation, moving coal to Lake Erie and iron ore to the Pittsburgh area it is estimated that transportation costs may be reduced by $1 to $1.50 per ton for coal and 43 to 68 c. per ton for iron ore. It is estimated that the conveyor will cost $210 million. For this project to be an economic success it will have to handle from 25 to 50 million tons annually. Where can volume movement of materials approaching these figures be found in one area, in the process industry?

The lower rates of water transportation are tempting more shippers who are geographically located to take advantage of these facilities. Fabrication of a quantity of barge towing units by Dravo Corp. for Butcher Arthur, Inc., has been recently announced. These barges designed for dry bulk cargo in two-barge towing units are to be operated between the Gulf Coast and the mid-continent area. Sulphur, salt and other chemicals are to be transported up stream and automobiles will be carried down stream. The welded steel barges are 240 ft. long and are designed to carry 2,500 tons of cargo at a speed of 10 to 11 mph. Loading and unloading are facilitated by 12 hatches equipped with weathertight rolling hatch covers.

A development for bulk transportation of flour has some interesting construction features which might prove useful in transporting powdered chemical products. Developed by the National Fitch Corp., special two-compartment railroad cars equipped with two top hatches for each compartment can be loaded by gravity at a rate of 80,000 lb. per hr. per hatch. These cars hold 140,000 lb. of flour. There is no condensation on the inside of the car even when loaded with hot material due to air breathers which cause inside atmospheric conditions to adjust with outside conditions. These cars are provided with traveling telescopic nozzles which break up packed masses of material allowing unloading by any conventional suction unloading equipment.

This company also manufactures portable tanks that can be mounted three to a special railroad flat car. Tanks are transferred mechanically to tractor trailer units designed for handling these tanks. Tanks are loaded and unloaded in the same manner as the bulk railroad cars.

A similar system for conveying liquids such as milk, wine, liquid sugar, chemicals, petroleum products, etc. has been manufactured by the same firm since 1939. Liquid tanks mounted

(Continued)

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two on special flat cars can be transferred in the same manner to trailer units for local delivery.

It is impossible to quote cost differentials which might be used in comparing movement of products by these systems. In general, freight rates are the same for packaged or bulk materials. Savings are limited to cost of containers and transportation on tare weights for packaged shipments. Portable tanks, tank cars, hopper bottom cars, etc. are either leased or owned. Mileage allowance by railroads may offset rental or maintenance and amortization of investment if owned. This depends on the rate of mileage travelled. For example, to offset tank car rental at present monthly rates, the car must travel about 2,250 mi. per month.

The investment of the customer in unloading and storage equipment is often sizable. An air system for moving pulverized dry materials from bulk conveyance to storage may cost in the neighborhood of $25,000 depending on the individual setup.

Shippers supplying customers whose requirements are not large enough to take advantage of bulk shipments are finding it difficult to offset increased transportation costs. Their only hope of relief lies in their ability to pack more efficiently, to use cheaper containers, and to find means of reducing warehousing and handling costs, including the loading, unloading and bracing freight cars.

Lifter-Dumper

A hydraulically operated lifter and dumper, exhibited at the last Materials Handling Show, is designed to overcome those troublesome jobs of lifting and dumping liquids or solids into high level tanks, or processing equipment. This device, manufactured by Lee Metal Products Co., Phillipsburg, Pa., can handle materials packed in bags or drums, and can pour to a maximum height of 50 in. It requires 28 x 72-in. floor space and an over-all height of 95 in.

Hoover Commission Recommendation

The Hoover Commission on Organization of the Executive Branch of the Government has recommended that all major transportation activities be grouped in the Department of Commerce. This would transfer to this Department matters referring to safety in rail, highway, air and water transportation now administered by Interstate Commerce Commission, Civil Aeronautical Board and the Coast Guard. Any changes that affect safety in transportation should be approached with the greatest of caution. The record of the Bureau of Explosives, acting as advisor to government agencies involved, is so good that it might prove unfortunate to disturb this set-up. It takes many years of experience to qualify for this work and it is doubtful whether any government agency has the needed background to administer these regulations unless they make use of the services of the Bureau of Explosives.

Bag Closing Machine

A new heat sealing machine for closing small bags operates without requiring attendant to feed the machine or to seal the bags. Bags travelling on conventional belt conveyors are straightened, positioned, and the mouths closed by the combined action of gripping chains as the containers enter a tapered guide. Bag tops can be folded over as they travel through the preheater. The operation is fully automatic. Manufacturer is Pack-Rite Machines, Milwaukee, Wis.

Dolly for Liquids

To improve efficiency in intra-plant movement of liquids, a 275-gal. tank mounted on a four-wheel dolly is available. Fabricated from aluminum or steel, the tank is mounted in a cradle and secured to the truck with heavy metal bands. The truck is 30 in. wide by 63¾ in. long and is equipped with two swivel caster wheels. It is made by Market Forge Co.

The use of equipment of this type to replace carboys, drums, etc. for moving liquids from storage to point of use should prove economical.

Sewing Machine Movie

Sewing machines used for closing open mouth bags are intricate instruments which require expert maintenance for efficient operation. Packaging conditions such as dusty areas

(Continued)

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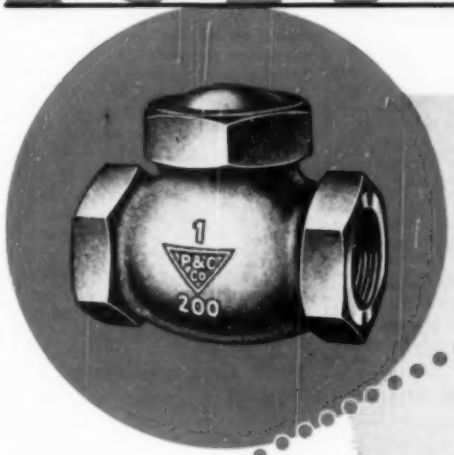

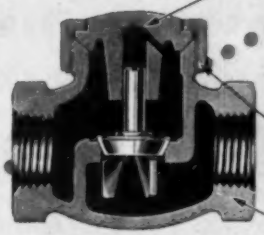

1 **CAP**—forms an efficient beveled joint with the body. The integral disc guide has long contact with the disc stem for perfect alignment and resulting free movement and positive seating. It also cushions disc movement.

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from stealing profits with
Pangborn
DUST CONTROL

and high speed production with unskilled operators often further complicate proper maintenance of sewing equipment. In recognition of this, Bemis Bro. Bag Co. has long maintained a staff of sewing machine experts to help their customers. They have been conducting clinics at which they instruct groups of machine users in proper operation and maintenance.

To supplement this work, Bemis now has a motion picture which covers installation, operation, maintenance and repair of sewing machines. It is expected that this film will be made available to industrial groups for instruction of plant personnel.

Loss and Damage Claims

In an address before the Society of Industrial Packaging and Materials Handling Engineers on the evening of March 15 in New York, H. H. Pratt, general traffic manager of Crucible Steel Co., emphasized the need for reduction of the loss and damage claims on the railroads. Stating that these charges amount to over $200,000,000 per year such losses are necessarily reflected in freight rates.

Mr. Pratt urged the railroads to enlist the help of the society in an effort to reduce these losses. An objective attack on the problem by packaging specialists could in his opinion find ways of making rapid improvement. The railroads' campaign of a "perfect shipping month" each year with continual publicity through the use of posters has been ineffectual and losses have continually mounted.

1949 Container Outlook

The Department of Commerce, in recognition of the growing importance of packaging, has been making a study of and gathering statistics on this industry. They started in February to publish a quarterly report entitled "Containers and Packaging." In the first issue they forecast that the 1949 supply of containers will continue near 1948 levels. Prices may decline approximately 5 percent due to softening in some types, particularly paper containers. Demand should level off during the first half of this year at a volume considerably in excess of that of prewar years.

Steel Drums and Pails—Production is expected to meet demand in almost all instances. With current production rates at the 1947 peak and with large stocks of reconditioned drums available, the supply outlook for the current year is good, even during the normal seasonal increases in demand.

Paper Shipping Sacks — Demand

(Continued)

IMPORTANT NEWS!

for users of Aluminum

United States Steel Supply Company has added aluminum to its line of products

Warehouses of the United States Steel Supply Company are now arranging to carry in stock a complete line of aluminum mill and building products manufactured by the Reynolds Metals Company.

This is further indication of the far-reaching expansion program of United States Steel Supply Company and its desire to satisfy more completely the metal requirements of its customers.

Initially, aluminum mill products — such as structurals, bars and sheets are stocked at the firm's Los Angeles, San Francisco, and Chicago warehouses.

Aluminum building products such as corrugated sheets, siding and other materials are in stock at Newark, Baltimore, Chicago, St. Paul, Milwaukee, St. Louis, Los Angeles and San Francisco warehouses.

Experienced technicians will be at customers' disposal at all times to help with problems involving application or fabrication.

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should continue strong in first half of 1949 but some reductions may be expected in the latter part of the year. In 1942 production of kraft paper for shipping sacks was 258,000 tons, in 1947 it had doubled, and in 1948 it will approximate 600,000 tons. There were 10 additional multi-wall sack manufacturing plants placed in operation in the last two years, increasing the total to 58.

Wooden Containers — All types were in free supply last year and no change in this situation is expected. Prices are weakening in some areas. Production of tight barrels is ample to supply requirements of which 75 percent is estimated to be for liquor.

Tight Cooperage — Fabricating plants have declined from 180 in 1944 to 75 now in operation. The decline in demand for slack barrels is attributed to high prices, competition from other types of containers and reduced production of products packed in these containers.

Textile Bags — Supplies of both burlap and cotton are ample and demand is declining.

Glass Containers—Production declined 14 percent in 1948 with little likelihood of 1949 exceeding last years demand. Production of closures for glass containers is ample to take care of demand.

Metal Cans—Deliveries during the first half of 1949 should be more prompt than in recent years and barring unforeseen difficulties they are expected to be able to supply all demands.

Corrugated and Solid Fiber Boxes—Shipments in 1949 are not expected to exceed last year's requirements. Supply is ample.

Note: Annual subscriptions to this quarterly, "Containers and Packaging" may be procured from Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C. for 60c. per year.—Editor.

Production of Steel Drums and Pails

(Index 1944 = 100)

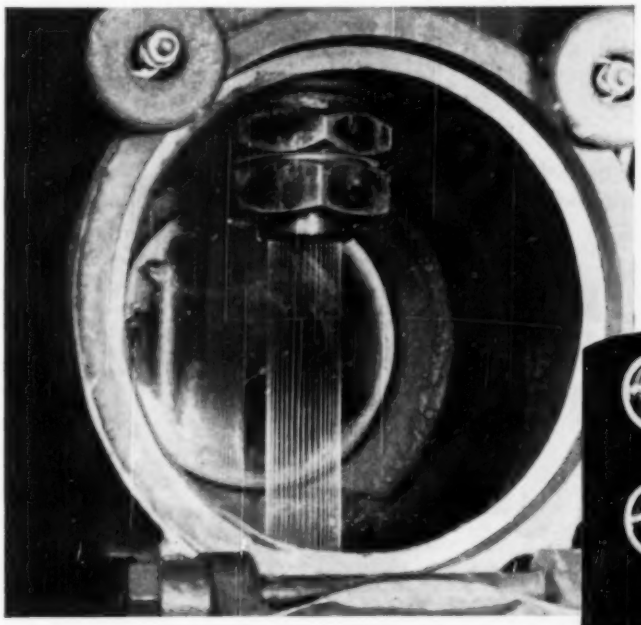
Year	Heavy Drums	Index	Light Drums	Index
1944	19,932,798	100	8,276,857	100
1945	22,240,723	112	9,948,835	120
1946	22,715,605	114	8,897,443	107
1947	27,065,471	136	8,798,168	106
1948	26,623,000	134	10,505,000	127

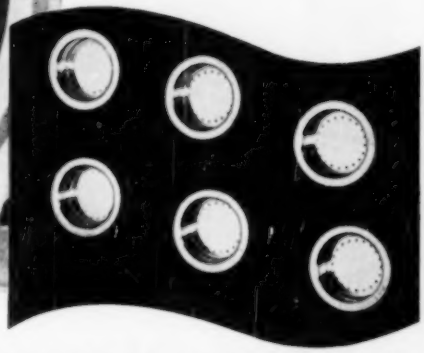
Year	Steel Packages, Kegs and Pails	Index	All Types	Index
1944	60,238,795	100	88,450,000	100
1945	62,313,495	103	94,503,053	107
1946	55,503,800	92	87,116,938	98
1947	61,071,535	101	90,935,174	110
1948	59,658,000	99	96,793,000	109

From "Containers and Packaging," Feb. 1949. Source: Bureau of Census. Figures for 1948 and total for 1944 are estimated

STAINLESS STEEL SPINNERETTES extrude a liquid synthetic which solidifies into fine, water-resistant yarn the instant it meets a stream of hot air. As loose rust and scale might plug tiny spinnerette holes, causing yarn imperfections, stainless steel's corrosion-resistance and ease of cleaning are vital. Stainless steel also protects yarn color and color stability against metallic-contamination effects. In its journey to spinnerettes, liquid "dope" travels through pipes, mixers, tanks of corrosion-resistant stainless steel.

Enduro-THRIFTY METAL OF 10,000 USES





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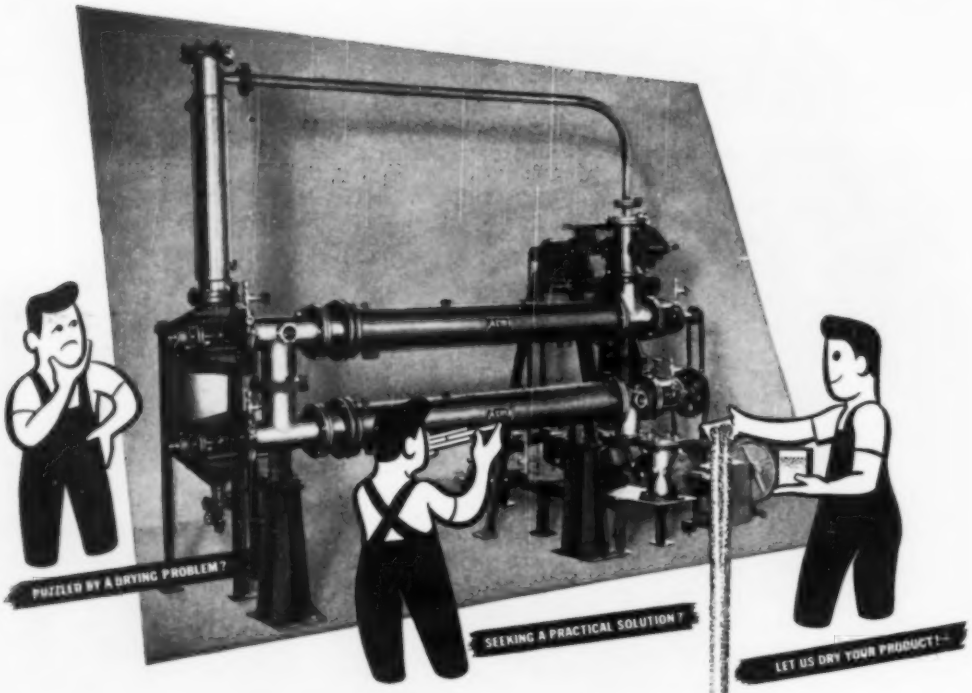

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Men, Machines and Methods

ROGER WILLIAMS, JR., *Assistant Editor*

Research And the Shift from a Sellers' To a Buyers' Market

C. S. BORUFF

The growth of industrial, institutional and governmental research in the United States has been phenomenal during the past few decades. With an annual expenditure approaching 1.5 billion dollars per year, research has become big business. In general, this growth has been justifiable. Modern industry depends on its research. In some industries such as electrical goods, special chemicals, special instruments, photography, pharmaceuticals, etc., research is the life blood. Inflationary periods always encourage research and investment of "venture capital." But what about research during deflationary periods?

Rate of business activity, prices and profits undergo constant change. Inflation has apparently reached a plateau and many think we will be faced in the future by a recession or depression to a lower plateau than we are on at the present time, but probably to a plateau much higher than that of pre-World War II. Regardless of whether one takes a pessimistic or optimistic view of the future, one must agree that business is no longer operating in a seller's market but is now operating in a buyer's market.

Management is organizing its thoughts and actions to meet these business changes. For example, the McGraw-Hill Business Survey[3] shows that industry, in spending 55 billion dollars in 1949 through 1953, will shift from an expansion to a modernization building plan. There is no question that the desire of American industry is to fulfill its responsibility to make its business and, in consequence, the nation secure, prosperous, and progressive.

Even though one of the fundamentals of industry and research under the free enterprise system is to furnish more, better, and cheaper goods for improving the living standards of all, it is questionable that demands will continue to exceed supplies and that sales and industrial growth will continue at the increasing rate they have enjoyed during the past 20 years. Industrial management is moving cautiously. Those serving industrial management through research and development must also examine their budgets, projects and aims to fit the present and future needs.

The magnificent return to industry and the American economy from its investment in basic and industrial research and development is a tribute to the quality of research administration. Research potentialities are still great but the task of its administration becomes more complicated as markets and business conditions undergo changes. Research must have the courage and forethought to modify its program to meet these changing conditions. Research directors must realize that under competitive business conditions, management expects research to be motivated by business considerations even more than by scientific interests.

Those who were research directors or research group leaders during the depression of 1930-33 have operated through a complete business cycle. Many research administrators, however, have not had this experience.

What are the "sights" that one should look through in adjusting a research program to this new set of business conditions? In this writer's opinion, if the research director understands, first, the purposes and aims of his management and, second, knows what his management expects of research, then he has the two necessary "sights" for guidance of his research. It is apparent that the above dictates that research be represented in management, or at least be working very closely with it. Without this close association, the research is, or soon will be, impotent.

Continuing the analogy, the front or fixed sight must be the plans of company management. The research director must know whether the management intention is to progress, to protect the status quo, or "to milk."

The second and adjustable sight is made up of those things which management expects from its investment in research. Various authors have stated these in many different ways[2, 6, 7]. They may be summarized as follows: (1) Improvement of existing products. (2) New products. (3) New or improved processes. (4) Reduction in cost of production. (5) Diversifications, within policy of the company. (6) Serving other departments of company. (7) Aid in management's planning; foreseeing, and meeting economic, social and industrial trends. (8) Build reservoir of applicable information. (9) Training personnel, research et al. (10) Maintain competitive technical position. (11) New and better uses of primary, secondary and byproducts. (12) Prevent processing and product troubles. (13) Better and/or cheaper raw material. (14) Keep in touch with market desires and trends. (15) Good customer and technical public relations.

It is difficult, if not impossible, to assign a percentage rating to each of the above. The importance of each will vary with the size of the company, the nature of the business, and economic and business conditions. The first four, however, are the direct "money makers."

THE RESEARCH PROJECT

Having a close understanding of the two above subjects and a clarification of the relative importance of each to his company, as worked out with top management, the research director is ready to select, evaluate, and organize his projects in line with business policies and anticipated business conditions. This does not necessarily mean cutting the budget. The Evans survey[4] showed that 73 percent of the companies surveyed made basic and applied research appropriations without reference to current business. Frequently research is more needed in depression than in boom times. The target, however, may be, and usually is, different. In depression or recession times, emphasis is usually placed on reduction in production costs, im-

(Continued)

C. S. Boruff is Technical Director of Hiram Walker & Sons, Inc., Peoria, Ill.

proved processes, new products and improvements in existing products. Various satisfactory methods of research evaluation are in operation. Regardless of the details of the method—some method must be used. This subject has been well covered in a recent publication of the Industrial Research Institute[4] and by other writers.[1, 2, 3, 5, 6, 7] A constant evaluation of old, as well as new and improved products and processes, is a necessary requirement for success under our present-day, fast moving industrial and changing economic conditions. The research director must always be in a position to prove the dollar value of his completed and current projects. Research "just for the heck of it" is a thing of the past.

RESEARCH STAFF ORIENTATION

Research aimed at changing economic conditions need not be demoralizing to a research organization if the staff is properly guided by the research management and brought to realize that the new program makes them even more of an integral part of the organization.

Research will continue to conduct its expeditions into the unknown and come out with ideas and data regarding new products, processes, uses, and so forth, but it cannot do the complete "idea to profits" job alone. There must be close two-way cooperation with the other operating departments of the company and with management. Top management must possess an understanding of and faith in research, have continuity of attitude to use as well as do research, must motivate and service it, and plan with the research director so that the most can be realized from the invested research dollar.

In the main, the above remarks have been directed to industrial research and development, but they also apply to institutional and government-sponsored projects.

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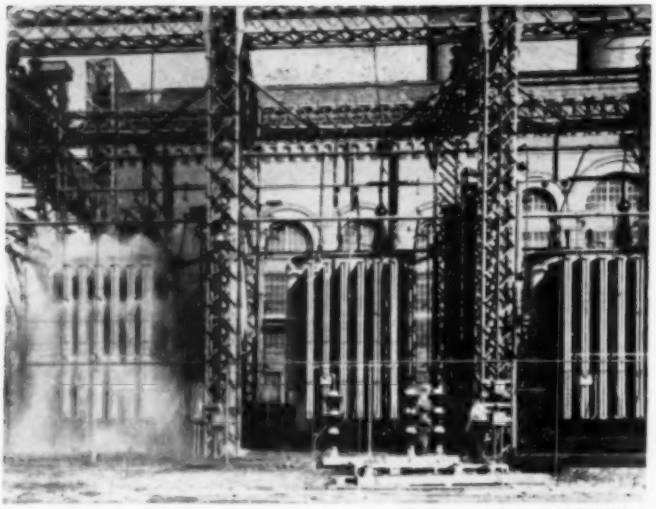

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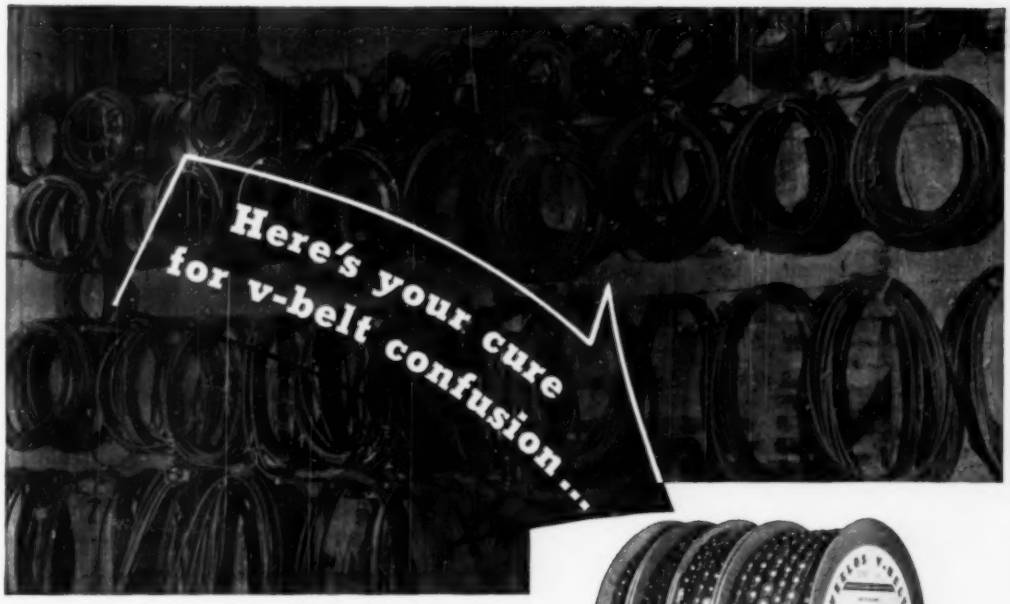

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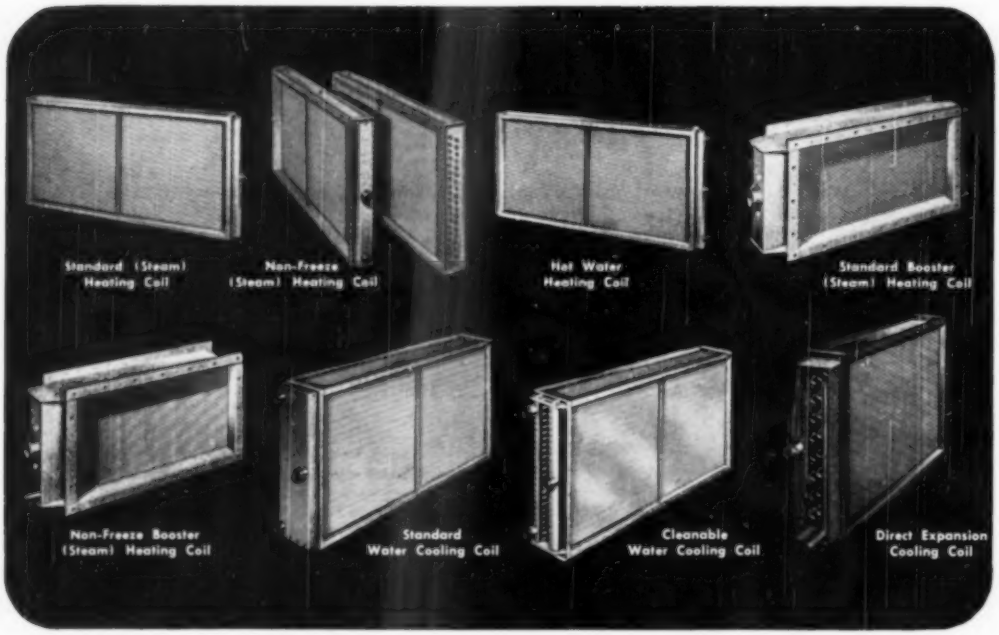
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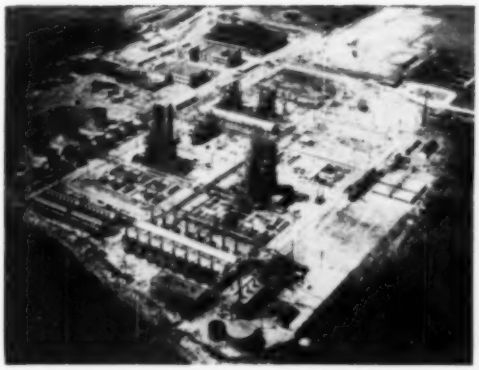

Texas City styrene plant, risen from its ashes, . . .

. . . has a memorial for those killed in disaster.

Monsanto Rededicates its Texas City Plant And Honors Those Who Died in Explosion

Monsanto Chemical Co.'s Texas City plant had about 1,000 guests on April 8. They came to witness the dedication of a memorial to the 145 employees of the plant who died following the explosion of ammonium nitrate on a ship in the vicinity. That was in April 1947. Joseph R. Mares, general manager of the company's Texas Division, and other company officials, presided at the ceremony. High point of the services came when a granite monument was unveiled at the main entrance to the rebuilt styrene plant.

The memorial is inscribed with the names of the men and women lost in the disaster, and with the statement that Edgar M. Queeny, chairman of the Monsanto board, made a few days after the tragedy: "The physical part of the men and plant have gone, but not the products of their minds. These will live on."

After the services the remainder of the morning was spent in a tour of the plant, where the company is again producing styrene, ingredient of general-purpose synthetic rubber and polystyrene plastics.

In the afternoon the program was shifted to Houston, where a symposium on "Gulf Coast Hydrocarbon Resources" was held at the new Shamrock Hotel. Speakers were Paul Weaver, chief geophysicist of Gulf Oil Corp., and past president of American Association of Petroleum Geophysicists; W. J. Murray, Jr., chairman, Texas Railroad Commission; and Richard Gonzales, economist, Humble Oil & Refining Co. Gonzalez said that as a result of the sharply increasing demand for natural gas for use in chemical plants in the Southwest and through pipeline movements out of the region, it is likely that the price of gas, at the well, will rise to as high as 20 c. per M cu. ft. in the near future. He remarked that the cost of pipeline transmission of

(*Continued*)

SALT LAKE GETS SOCAL REFINERY

From Colorado's booming Rangeley Field pipeline comes oil to run this refinery. About 22,000 bbl. per day are fed into the unit, which will serve the inter mountain market. Products range from gasoline to heavy fuel oils. Engineers are using dissolved gilsonite in the charging stock on an experimental basis. Standard of Calif.'s Salt Lake Refining Co. runs it.

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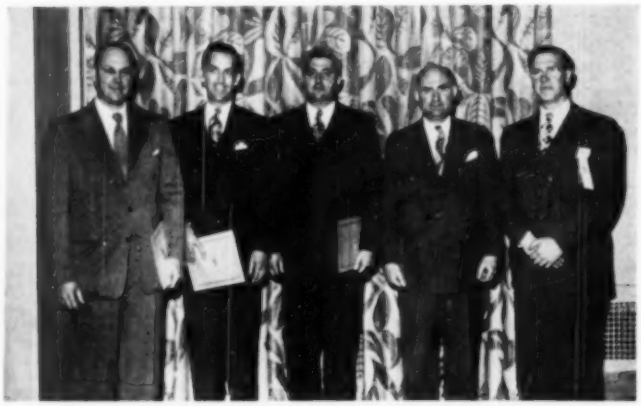
gas is about 1.4 c. per M cu. ft. per 100 mi. of line; this figure includes all capital and operating items and applies to lines having diameters of 20 in and larger.

Speakers at the dinner following the symposium were William M. Rand, Monsanto president; Karl T. Compton, chairman of the board, Massachusetts Institute of Technology; and Warren S. Bellows, president, Houston Chamber of Commerce.



Leather outlook was discussed by J. R. Hoover, A. H. Winheim, E. S. Flinn, and S. J. Kennedy. R. M. Lawrence (right) served as moderator.

Market Research Problems Aired at St. Louis

Where does market research belong in a chemical company? This was the subject of a fast moving discussion by six roundtable-panels made up of Chemical Market Research Association members and guests at the recent St. Louis meeting. Various members explained where it fitted into their companies and how it worked in practice. The general opinion seemed to indicate that the closer the market research department got to top management the better its service to the company would become. Actual title of the man to whom the market research director reports appears to vary with different firms. Training for market research was also discussed.

High point of the meeting was a comprehensive discussion of the leather tanning industry. A movie of the tanning industry was shown by the Tanner's Council of America. Following the showing of the film, a luncheon meeting featured a talk by Stephen J. Kennedy, Office of the Quartermaster General, which described the role of the leather industry in national defense.

Chemical requirements of the tanning industry were outlined in a paper by Kenneth E. Bell, vice president, A. C. Lawrence Leather Co., and Edward S. Flinn, manager of the tannin division, Mead Corp. Dr. Flinn delivered the paper and Ade Winheim, president of Planetary Chemicals, described present and future tanning processes. Last but far from least, John R. Hoover, vice president of Goodrich Chemical Co., discussed invasion of plastics into leather markets.

Due to the illness of Francis J. Curtis, vice president of Monsanto Chemical Co., Dr. W. S. Calcott of Du Pont's organic chemicals department delivered Dr. Curtis' talk on opportunities in the chemical industry.

In addition to these papers, a morning session of the meeting discussed industrial market research. Speakers were Harvey W. Huegy, professor of marketing at University of Illinois and Bay E. Estes, manager of market research for U. S. Steel Corp. of Delaware. In the afternoon a talk on plant location problems was featured. The speaker was Dr. L. E. Stout, dean of the engineering school, Washington University, St. Louis, Mo.

Permanente Builds Bigger Aluminum Market

There's one sure way to sell more aluminum: develop new and better products from it and then tell your customers how to make them. That's what Kaiser's Permanente Metals Corp. thinks. So a topnotch research division was born, and the firm has built new laboratories near Spokane. The setup is probably the most mod-

ern and complete in the entire aluminum industry. Dana W. Smith is the division's chief metallurgist.

Permanente's research and development division has three functions: (1) Develop new and improved metallurgical products and processes through coordinated research. (2) Give technical service and advice to Permanente's reduction and fabricating division. (3) Pass along useful findings to the users of aluminum and aluminum alloy products. To do all this, Permanente set up different laboratory departments in its division of metallurgical research. The process metallurgy group at Trentwood will handle the physical chemistry behind the reduction process. Interesting revelations are already on the horizon. Development of new and improved aluminum alloys and fabricating methods will be the chief concern of the physical metallurgy departments. The fusion joining laboratory will concentrate its efforts on welding, brazing and soldering. The corrosion group will study the corrosion resistance of alloys under accelerated and natural environment conditions. Fundamental work on the mechanisms of corrosion is under way now. The metal finishing laboratories are well fitted to study various paint, organic, electrochemical, metal-sprayed and ceramic finishes. Other research subdivisions will specialize on structural design and testing of alloys, metallography and X-ray diffraction.

Tonnage Oxygen Plant On Stream in Texas

First low-cost oxygen plant of commercially substantial tonnage output, to be built for the petrochemical industries was opened in Winnie, Tex., as an integral part of a petrochemical plant recently completed by the McCarthy Chemical Co., the new oxygen unit is now producing more than the design quantity of 175 tons (4,200,000 cu. ft.) per day of 90-95 percent pure oxygen which is delivered at 800 psig.

A feature of this process is a low-pressure, self-contained cycle, a far-reaching improvement over the original German process which required up to 10 percent high pressure chemically purified air. The new system requires no chemicals, using only cooling water and a source of fuel gas. Air is merely compressed to 85 psig., cooled by expansion and self-refrigeration, and the CO_2 and other impurities removed by depositing them on special aluminum fin-tube reversing exchangers, separating the oxygen from the nitrogen in aluminum fractionating columns.

Among the Dresser Industries units

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Typical applications include: water drainage . . . pumping heavy viscous or high temperature liquids . . . pumping quenching oil . . . hot water and other liquids in heat-treating processes . . . handling hot drainage, such as boiler blow-off, heating returns, etc. . . . screened sewage, etc.

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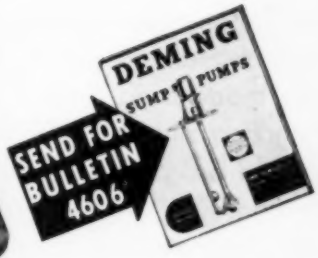

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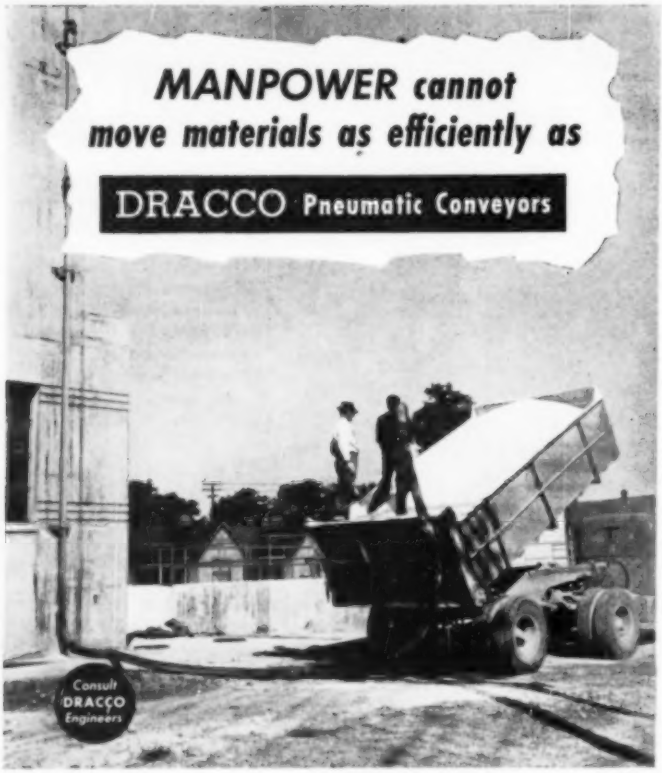

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contributing to work on the plant were: Stacey-Dresser Engineering Division, Clark Bros. Co., Stacey Bros. Gas Construction Co., and Pacific Pumps, Inc.

Carbide Plans Ohio Valley Production Center

Contracts are in the last stages of negotiation for the initial units of the $50,000,000 industrial development planned by the Union Carbide & Carbon Co. between Marietta, Ohio, and Parkersburg, W. Va. Construction of the power plant for the three-factory development will start within the next few months, according to reports.

The three plants will be operated by the Electro-Metallurgical, Bakelite, and National Carbon Division of the Union Carbide & Carbon Co. Electro-Metallurgical plant will manufacture alloy steels in large electrical furnaces, Bakelite will make plastics, and National Carbon will produce a variety of carbon products, mainly for industrial use.

One power plant will supply electricity for all three plants. Union Carbide & Carbon has bought out the

(Continued)

CONVENTION CALENDAR

American Association of Cereal Chemists, annual meeting, Statler Hotel, New York, May 16-20.

Society for Experimental Stress Analysis, spring meeting, Hotel Statler, Detroit, May 19-21.

Society of The Plastics Industry, annual meeting, Edgewater Beach Hotel, Chicago, May 26-27.

Chemical Institute of Canada, Halifax, N. S., May 30-June 1.

Manufacturing Chemists Association, annual meeting, Skytop, Pa., June 2.

Chemical Market Research Association, annual meeting, Biltmore Hotel, New York, June 9.

Commercial Chemical Development Association, summer meeting, Niagara Falls, N. Y., June 24.

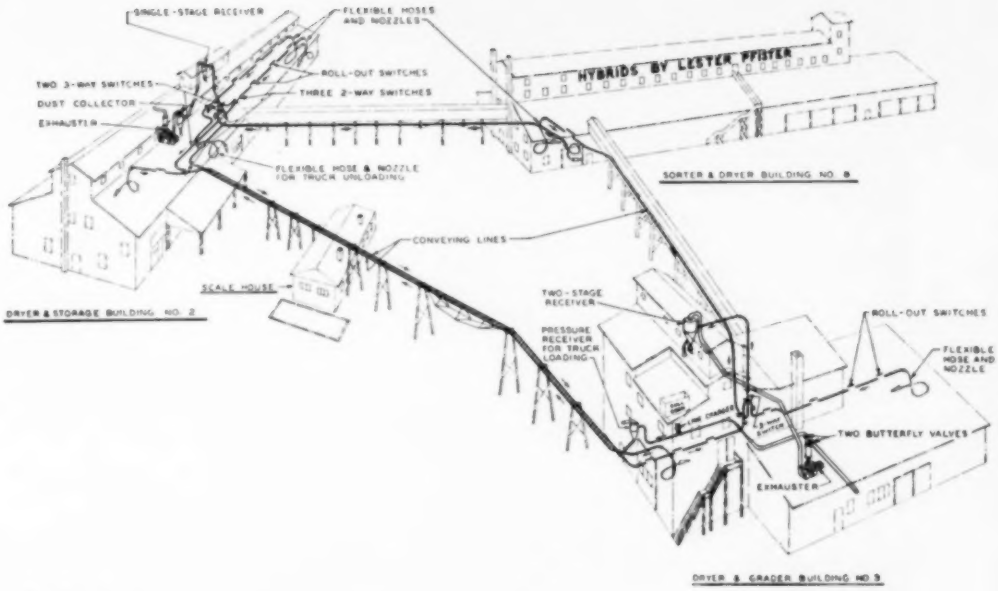
American Institute of Chemical Engineers, regional meeting, Mount Royal Hotel, Montreal, September 6-8.

American Chemical Society, 116th national meeting, Atlantic City, N. J., September 18-23.

Packaging Institute, annual forum, Commodore Hotel, New York, October 24-26.

22nd Exposition of Chemical Industries, Grand Central Palace, New York, November 28-December 3.

American Institute of Chemical Engineers, annual meeting, William Penn Hotel, Pittsburgh, Pa., December 4-7.



The AIRVEYOR serves 243 bins at Pfister Hybrid Corn Company

Conveying a product like hybrid seed corn, which has a high-market value, with a minimum of breakage, is quite a trick . . . serving 243 bins, is more of a trick. But that's what the Airveyor does at Pfister Hybrid Corn Company's El Paso, Illinois, plant.

Really, it's no trick at all; just good, common-sense engineering . . . the "know-how" of pneumatic conveying . . . experience and knowledge gathered by Fuller engineers during many years of materials handling.

The drawing above shows the Airveyor installation at Pfister. The first of these was installed, about eight years ago, in building No. 3, for conveying shelled corn, by vacuum, from any one of 243 bins in three seed houses, No. 2, No. 3, and No. 8, to control points above grading equipment in building No. 3. The capacity of this system is 550 bushels an hour, and corn is conveyed over distances ranging from 50 to 500 feet. Due to increased production, a second Airveyor was installed in building No. 2, to convey, by vacuum, from building No. 3 and No. 8. The original system is still used for loading cull corn into trucks, through a pressure receiver, at the north end of building No. 3.

The drawing does not show, in detail, the bins served by the Airveyor. However, through the simplicity and flexibility of the conveying line layout, and the use of two-way, three-way, and roll-out switches, corn is conveniently and efficiently handled from 34 dryer bins and 14 ear-sorter bins in building No. 8; 20 dryer bins, 20 storage bins, 51 grading bins, and 4 basement vaults in building No. 3; 16 dryer bins and 84 storage bins in building No. 2.

The simplicity and adaptability of the Airveyor, as applied in this plant, can very well be appreciated, when compared with the many difficulties to be encountered through the use of mechanical systems to accomplish the same results.

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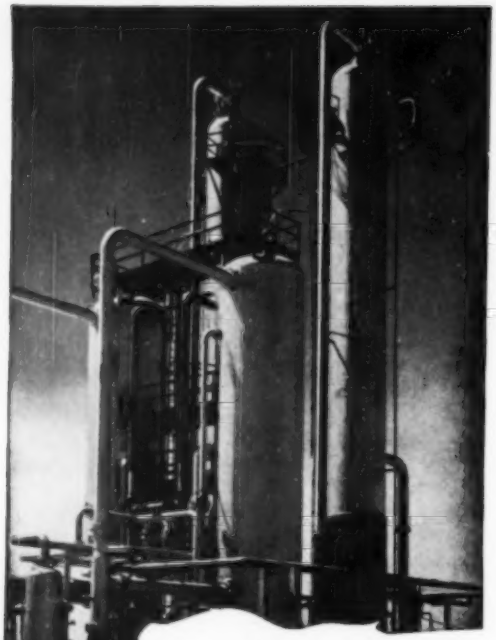

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strip mining interests of Testa Bros. in four southeastern Ohio counties to act as the backbone of the coal supply for the power plant. Other mining properties have also been acquired for this purpose.

Esso Celebrates Fortieth Anniversary

Esso Standard Oil Co., which began operations in Louisiana on Apr. 13, 1909, celebrated its 40th anniversary last month with a state-wide program. Ceremonies were held at the Baton Rouge refinery, where addresses were made by Cecil Morgan, vice president, H. J. Voorhies, general manager, and other officials. Over 1,300 independent Esso dealers in Louisiana conducted local programs.

Shell Shifts Agricultural Chemicals Sales Set-up

Shell Chemical Corp. has taken over the marketing of agricultural products formerly sold by Shell Oil Co. Administrative offices of Shell Chemical's agricultural products department are at 50 West 50th St., New York. F. W. Hatch will be in charge of the department.

In the last decade Shell Oil has been producing and marketing insecticides, and in recent years has developed weed killers and plant hormones. Shell Chemical's developments in agricultural work have included the use of ammonia as a commercial fertilizer and the adaptation of conventional farm machinery for applying it to the soil. The Shell Agricultural Laboratory at Modesto, Calif., will continue to develop farm chemicals in connection with its 142-acre experimental farm established three years ago.

New Engineering Firm Born in Houston

A new engineering organization, the Wyatt C. Hedrick Engineering Corp., has been formed in Houston. The company is headed by G. M. McGranahan as president who had been vice president and general manager of McCarthy Chemical Co. In addition to McGranahan, officers include Wyatt C. Hedrick and H. H. Bowen, both vice presidents. The new company will engage in engineering design and construction primarily in the field of petroleum and petroleum-based chemicals, and also contemplates entering into operating contracts. The firm's offices in Houston are at 5214 San Jacinto St.

(*Continued*)

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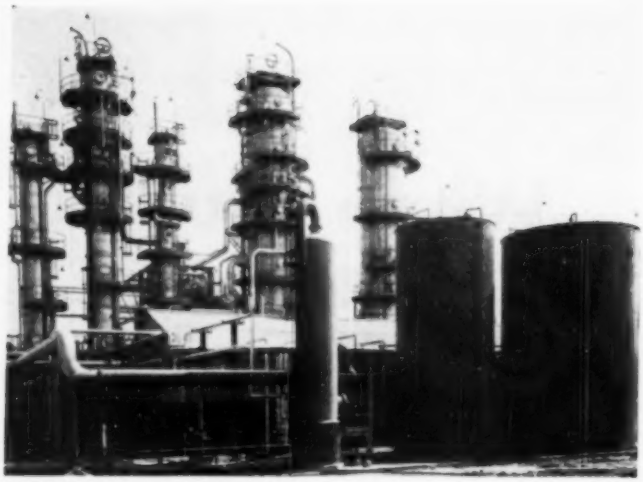

PHENOL EXTRACTION AT HOUSTON

Shell's phenol extraction section in the combination lube unit at Houston has a capacity of 5,800 bbl. per day. Heating is done in the furnaces (foreground). The five towers (background) treat and remove the phenol.

NEWS, *cont* . . .

McGranahan joined McCarthy in January 1946 to take over the management of the newly organized McCarthy Chemical Co., whose plant for manufacturing formaldehyde, methanol and acetaldehyde is at Winnie, Tex. Prior to joining McCarthy, *(Continued)*

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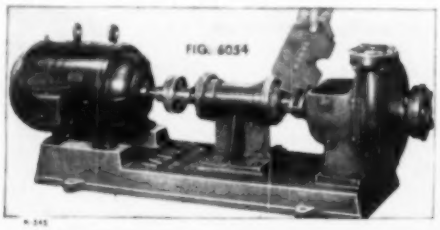

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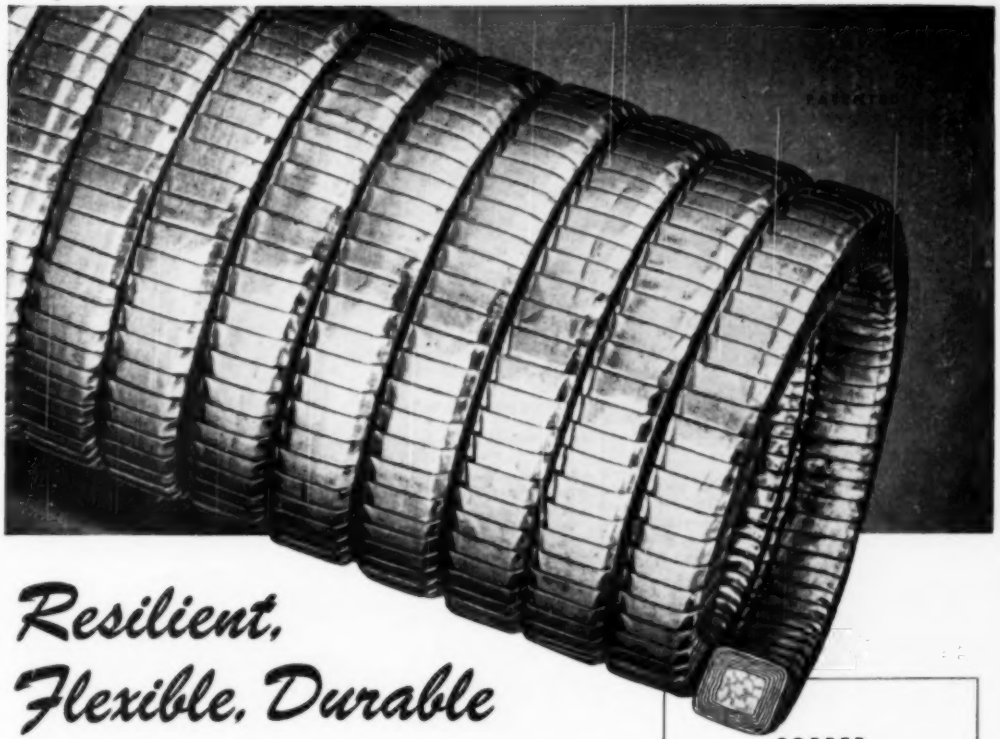

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To give you *both* of these desirable qualities, Garlock has developed a new line of Metal Foil Packings by wrapping a thin metal foil spirally around a fibrous center core.

A patented, pleated foil construction used in several of these new Garlock packings imparts unusual flexibility to the packing and permits the forming of rings without undue distortion of the material. Also the many small pockets in the pleats or folds of the foil carry lubricant or graphite to the wearing surface of the packing.

Garlock Metal Foil Packings are recommended for centrifugal or reciprocating pumps, compressors, engines, expansion joints, etc. Write for descriptive folder.

THE GARLOCK PACKING COMPANY
PALMYRA, NEW YORK
In Canada: The Garlock Packing Co. of Canada Ltd., Montreal, Que.

COPPER

GARLOCK 906—Pleated copper foil with asbestos core for steam, air or gases (except ammonia) and hot oils of low sulphur content, at temperatures up to 1000° F.

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GARLOCK 913—Pleated aluminum foil with asbestos core for hot oils at temperatures up to 1000° F.

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GARLOCK 917—Pleated lead foil with asbestos core for steam, air, oil, water, ammonia or other gases at temperatures up to 550° F.

GARLOCK METAL FOIL PACKINGS

. . . with permanent buildings that can meet your exact requirements

Luria now offers a complete line of standard, heavy steel-frame structures that cost little or no more than light-weight, temporary buildings. Moreover, they offer such a wide range of sizes, optional features and collateral materials that they are easily adaptable for anything from a small utility building to a complete plant. And Luria buildings are available now — many sizes carried in stock ready for immediate delivery. Write today for our new 20-page catalog on the complete Luria line.

FEATURES

- Rigid-Frame Construction, without space-consuming trusses
- Clear spans of 40 to 100 feet
- Eave heights of 12 to 20 feet
- Lengths as desired in 20-foot increments
- Wide choice of standard alternates, optional features, and collateral materials.

Standard Buildings by LURIA

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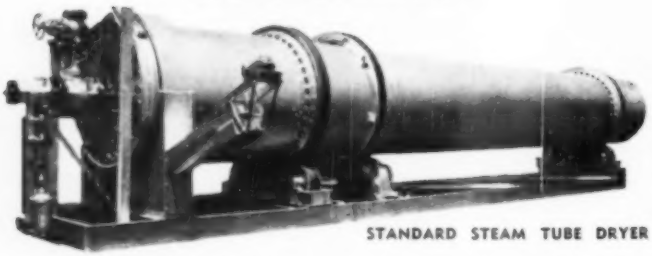
500 Fifth Avenue, New York 18, N. Y.

STANDARD



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DRYERS—DRYERS—DRYERS

STANDARD Rotary dryers are used throughout the world. STANDARD dryers are competently engineered and sturdily built in a wide variety of types and sizes for drying various products, such as fish meal, garbage, tankage, humus, fertilizer, sewage, sludge, agricultural products and countless chemicals. Stock designs available in sizes of 2 feet to 10 feet diameters. Let our engineers help you with your problems—regardless of your location.

We welcome your inquiries.

STANDARD STEEL CORPORATION

Engineers—Manufacturers

5005 Boyle Avenue — Los Angeles, Cal.

McGranahan was assistant manager of the Dow Chemical Co. plant at Freeport, Tex. He had been with Dow for 17 years.

Hedrick has been engaged since 1913 at Houston in architectural and engineering design for industrial and commercial construction.

Leland I. Doan

Mark E. Putnam

Shifts in Dow's Top Executive Staff

Several shifts in the top executive staff of the Dow Chemical Co. were made in April by the board of directors as a result of the death of Dr. Willard H. Dow in a plane crash near London, Ontario.

Earl W. Bennett, treasurer of the company since 1930, was elected chairman of the board, and Leland I. Doan was elected president. Mr. Doan had been a vice president since 1938 and secretary since 1941. Dr. Mark E. Putnam, a vice president since 1942, was named general manager.

Dr. Dow had formerly held all three of the positions thus filled but in recent years had abandoned the titles of

(Continued)

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Remember
"ORIAD"...it means...
Oil Refinery Instrument Air Dryer.

Some processes can't stand moisture...
Some instruments won't work when wet...
Some tools break down from dampness.

When you get rid of water AND water vapor you get rid of these irksome difficulties.

Kemp "Dynamic" Dryers adsorb water AND water vapor... reliably, automatically, positively, and at absurdly low cost!

You can have little portable Kemp Dryers for small rooms or local work...or great twin-tower jobs. They will dry airplane cylinders for delivery or dry air for wind-tunnels . . . to dew-points as low as −60°F.

A note on the coupon below will bring you a skilled Kemp engineer or a 48-page booklet on Kemp Dryers.

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Please send a Kemp representative in to see me. ☐

Please send me your NEW Bulletin No. 25-D on Kemp Dryers. ☐

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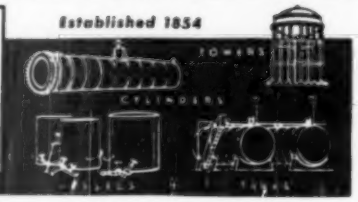
• For water when you need it, you can't beat an elevated tank. Backed by 95 years' experience in tank design and fabrication, you can rely on COLE tanks to more than meet insurance requirements and ASME standards, and to provide you with an extra margin of safety.

Whether you desire a tank of 5,000 or 2,000,000 gallons—Cole engineers will give you the *right* design for the specifications. Write for the latest Cole catalog—"Tank Talk."

R.D. COLE
MANUFACTURING CO.
NEWNAN, GA.

Established 1854



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ANYTHING
PRE-FABRICATED
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You wouldn't want anything like this but, if you did, we could furnish 1 or a 1000 and 1—to your specifications—and all alike. Over a score of years ago, we pioneered in developing methods for welding and shop pre-fabrication of stainless steel piping. We've gained much experience since then, and today, we use the latest "inert-gas-shielded-arc" welding, available for commercial users only since the war. No job is too large or too small for our facilities and none too difficult for our engineering experience. We can get the alloy materials, particularly stainless, in any quantity and give you prompt service. Our engineering "know-how" in power and process piping has been established over a period of a half a century and today most utilities know the perfection of our patented Westport Welded Joint and other high pressure, high temperature pipe engineering and pre-fabrication.

1899 • OUR 50th YEAR • 1949

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PIPING FABRICATORS AND CONTRACTORS

chairman of the board and general manager.

In the same action two new vice presidents were named: Dr. A. P. Beutel, who is general manager of Dow's Texas Division, and Russell L. Curtis, general manager of the Great Western Division. Carl A. Gerstacker was elected treasurer and Calvin A. Campbell, the firm's legal counsel, was elected secretary.

New Fertilizer Mixing Plant in Oklahoma

Construction of a fertilizer mixing plant at Muskogee, Okla., to be operated by Consumers Cooperative Association is expected to begin soon. Contract for the construction, expected to cost in excess of $30,000, was let in February to Ditmars-Dickmann-Pickens Construction Co. of Muskogee.

K. A. Schmitt, who has been named as manager, says the plant will probably be the most nearly automatic of its type in the country and will produce 25,000 to 30,000 tons per year.

Girdler Gets Contract For New Ammonia Unit

Mississippi Chemical Corp. has named Girdler Corp. as engineer and general contractor to build Mississippi's 120-ton-per-day anhydrous ammonia plant at an estimated cost of approximately $10 million. A few months ago Girdler had been chosen to handle the preliminary survey for the project. A site near Yazoo City, Miss., has been selected. The selection of that locality was made on the basis of availability of natural gas, a favorable ad valorem tax structure and an attractive local market.

About 60 tons of the total daily ammonia capacity is scheduled to be converted into ammonium nitrate fertilizer, though this figure is subject to change. Negotiations were near completion last month whereby natural gas would be secured from Southern Natural Gas Co. of Birmingham, Ala.

Tulsa May Be Site of New Fiberglas Plant

Selection of Tulsa, Okla., as the site for a plant to manufacture insulating products from glass was being given serious consideration last month by Owens-Corning Fiberglas Corp. Harold Boeschenstein, president, said the company's interest in Tulsa lay in the availability of natural gas, silica sand and other raw materials and the

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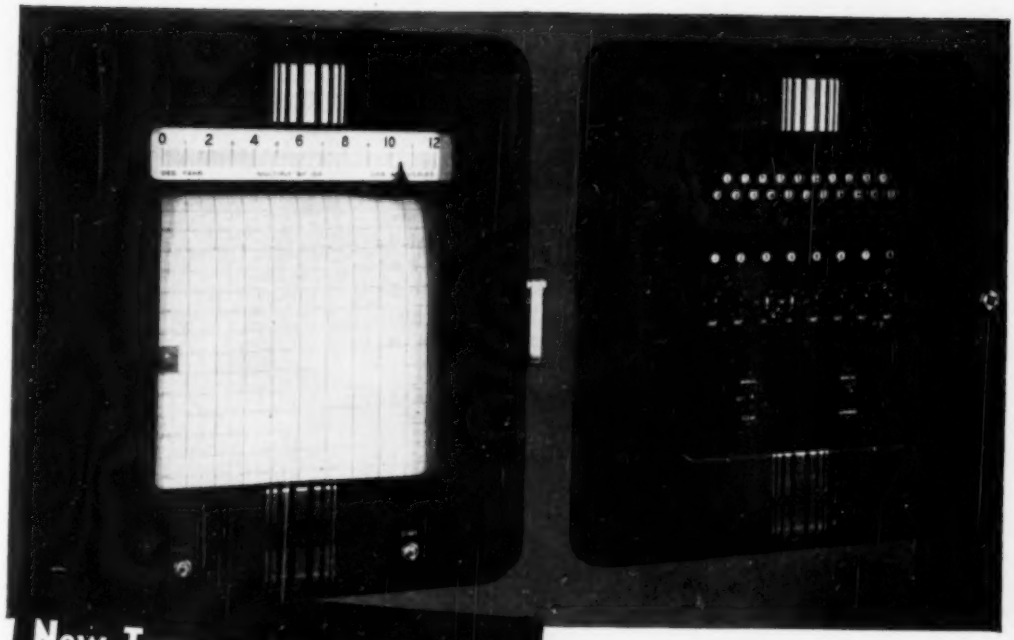

New Temperature Instrument For Testing and Processing

Checks 160 Points In Only 10.6 Minutes!

Remarkably fast, this new Speedomax is industry's new version of the well-known L&N wartime Flight Test Recorder. It offers a definite advance in temperature checking and recording for the chemical processing industries. With Speedomax, an operator can "tour" the temperatures of 160 points in a little less than eleven minutes. He can watch the readings as they are automatically indicated; or Speedomax will record them for later examination and for the shift log.

In either case, readings are supplied in such rapid rotation that it is generally possible to determine the exact point at which any high or low temperature first develops, even though the condition may later spread to other points. Such speed of course helps both to detect and to isolate trouble.

The installation procedure is entirely standard. The user's staff simply installs thermocouples at those points from which they wish to get temperature readings. Couples are then connected to the Speedomax equipment in banks of 20 each, with as many as 8 banks. Appropriate alarms may be included.

Records When Desired

The Speedomax automatically measures at a rate of one every 4 seconds. Signal lights wink on for each couple, and as long as temperature remains correct the instrument merely indicates . . . does not record. It can be made to record at any time, however, merely by throwing a switch. Or if any temperature reaches its predetermined limit, an alarm sounds and the Speedomax automatically records until switched off. Also, any bank or banks of couples can be switched out at any time, thus concentrating on areas of special interest.

For further information about this verastile temperature-checking equipment, write Leeds & Northrup Co., 4916 Stenton Avenue, Phila. 44, Penna.

Substantially the same equipment can be used for Machine, Turbine and Generator-Bearing Temperatures.

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LEEDS & NORTHRUP CO.

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PALMETTO'S SUPER-CUTNO

Built to take the punishment of sulphuric, nitric, mixed, heavy and other acids -- and service on all acid-handling pumps and valves. Select long fibre pure blue asbestos . . . each strand impregnated with special acid-resisting self lubricant. Will not score, overheat, or nitrate. Plaited, twisted, ring.

Let Palmetto Blue Asbestos also take the bite out of acid problems as pressure-bonded Sheet, as Dry Blue Rope.

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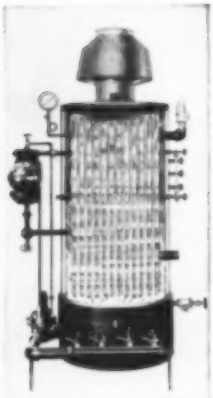
Contact your fully-stocked Palmetto distributor on all packing problems . . . ask him about our special tools.

STEAM—AS YOU WANT IT . . . WHERE YOU WANT IT



The KANE Boiler is built to A.S.M.E. specifications, in sizes to 30 H.P.

THE **KANE BOILER PACKAGE**

Each KANE BOILER PACKAGE is carefully considered by us as an "individual" job,—from the customer's requirements to the finished unit. And each BOILER PACKAGE is a compact, self-contained steam source that includes: the correctly sized KANE Automatic Gas-Fired Boiler complete with gas burner and controls to maintain required steam pressure; and an M-K-O Automatic Boiler Feed system designed to return condensate and supply make-up water as required for highest operating efficiency.

Engineered Steam at its best with four decades of experience at your disposal—so, send your steam problem to us for study and recommendation.

ENGINEERED STEAM AT ITS BEST

MEARS-KANE-OFELDT INC.

1903-1915 EAST HAGERT STREET, PHILADELPHIA 25, PA.

FOUR DECADES OF AUTOMATIC GAS-FIRED BOILER MANUFACTURING EXPERIENCE

fact that "Tulsa and the Southwest offers a great marketing outlet for the products we manufacture." Boeschenstein has visited several localities in the Southwest during the last few weeks, including Dallas, Houston and Waco, Tex.

Oklahoma has very large reserves of natural gas, glass sand and limestone. At present the state has 14 glass manufacturing plants, although between 1914 and 1928 the number reached a peak of 20. Chief handicap of the Oklahoma glass industry has been the lack of nearby large markets. In an address delivered last October before the Oklahoma Industrial and Mineral Industries Conference, Jay Randolph, Liberty Glass Co., Sapulpa, said, "With all her advantages, why has the Oklahoma glass industry grown so slowly? We can see only one answer to her ups and downs and her slow advancement—the distance to big markets. . . Our shipping facilities are adequate, but freight rates are now a decided handicap and in the future promise to be even worse."

Fluidization Nomenclature And Symbols

Recognizing the need for a commonly acceptable list of terms identifying the major conditions encountered in the field of fluidization a group representing the AIChE, the ACS, industry, the technical press and education have met and prepared a list of terms and symbols that might be acceptable for use in the field.

DEFINITIONS

1. A "fixed bed" is a body of motionless solid particles supported by direct contact with each other and the retaining walls.

2. A "moving bed" is a similar body in which the particles remain in direct contact and are substantially fixed in position with respect to each other, but move with respect to the retaining walls.

3. A "fluidized mass" of solid particles is one which exhibits the mobility and hydrostatic pressure characteristic of a fluid.

4. A "fluidized bed" is a mass of solid particles which exhibits the liquid-like characteristics of mobility, hydrostatic pressure, and an observable upper free surface or boundary zone across which a marked change in concentration of particles occurs.

4a. "Particulate fluidization" of a bed refers to a condition in which the particles are individually uniformly dispersed. (Particulate fluidization is

(*Continued*)

THE DE LAVAL SUBMERGED SUCTION PRIMING SYSTEM

De Laval pump fitted with submerged suction priming system.

As soon as the pump is started the De Laval submerged suction priming system automatically floods the pump to the eye of the impeller.

With the De Laval Priming System the pump cannot be started unprimed. Were the air inleakage too great for the priming system to handle, the pump would automatically be shut down and could not be started again until the fault had been corrected.

The pumping unit can be started or stopped at any time, from a remote control point, if desired.

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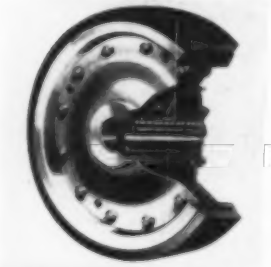

Free Manual

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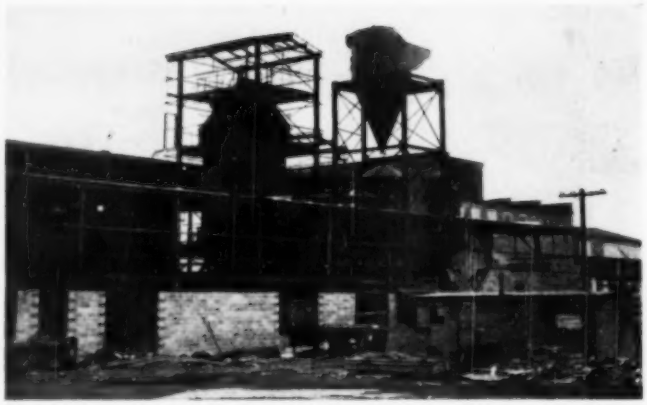

BOLIVIAN ORE WILL BECOME TIN HERE

This country's first privately-owned tin smelting plant is being built at Sewaren, N. J. Vulcan Detinning Co. is building the smelter for treatment of Bolivian ores. The unit will make five tons of refined tin daily.

NEWS, cont. . .

commonly observed in beds fluidized by a current of liquid. The term "teetering" as used in the ore-dressing industry refers to a relatively high-density suspension of this type). In contrast, coexistence of dense and dilute suspensions (bubbles) within a fluidized bed is termed "aggregative fluidization."

4b. A "quiescent fluidized bed is a dense fluidized bed which exhibits little or no mixing of the solid particles.

5. A "dispersed suspension" is a mass of solid particles or aggregates

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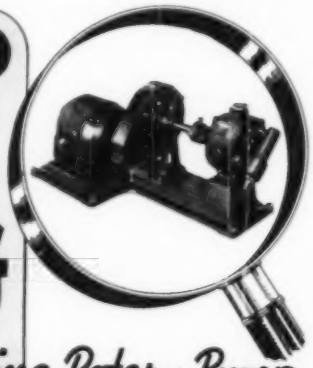
LOOKING? LEARN ABOUT VIKING



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If you are looking for pumps that will give dependable, trouble-free service, learn about Vikings! Simple gear within-a-gear design, with two moving parts, and rugged precision construction fit Vikings for the toughest kind of pumping jobs you can have. You'll find a Viking pump in the style and size you need, correctly engineered to do your job . . . to handle any clean liquids, regardless of viscosity.

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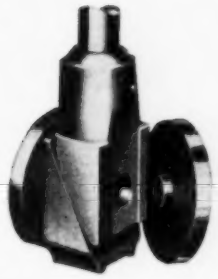
How Darling features prevent trouble and expense

UNIFORM WEAR DISTRIBUTION



A LARGE percentage of valve leaks, lost time, expense, can be blamed on uneven wear—the uneven wear caused by repeatedly exposing the same disc and seat areas to concentrated pressure, fluid flow, and resultant galling from operation.

For years such leaks were considered the result of normal, expected wear. But the unique design of Darling Double Disc Parallel Seat Gate Valves has proved that uneven wear can be prevented. The two valve discs shown in the cutaway view, and again in the removed inside assembly, are separately and independently hung and free to revolve through their 360°. Valve operation aids the action during the lowering and raising of the disc assembly. The discs never seat twice in the same position and obviously wear is bound to be uniform. This results in tight closure even when the disc faces are worn.

Hundreds of Darling gate valve users have learned by experience that uniform wear distribution results in longer service life and correspondingly lower maintenance cost.

DARLING VALVE & MANUFACTURING CO.
Williamsport 3, Pa.

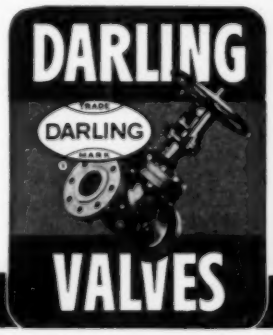
"This advertisement is one of a series showing how the unique Darling Fully Revolving Double Disc Parallel Seat Gate Valves answer the following critical operating problems:

- *Positive, easy closing—regardless.*
- *Automatic adjustment for valve body distortion.*
- *Elimination of disc-to-seat friction and galling.*
- *Uniform wear distribution.*
- *Extreme simplicity.*
- *Greater service life.*
- *Simplified maintenance.*

CORROSION RESISTANT VALVES

In addition to conventional iron, bronze and steel constructions, Darling specializes in valves for any corrosive fluid: iron body valves with special alloy trim; iron body, rubber lined, with special alloy trim; all bronze; and all special alloy. Darling's 50 years of experience in meeting unusual requirements is always at your service.

Outline your service requirements and get complete information on Darling Valves of the proper type. Or, send for the complete 300-page Darling Catalog No. 17M. It describes Darling Valves of all types for every normal or unusual service, and for pressures up to 1500 pounds. It's full of helpful information... Yours for the asking.



THE VALVE MARK OF QUALITY . . . WATCH FOR IT

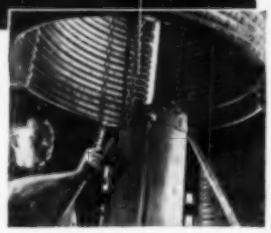
Take advantage of this

UNEQUALED EXPERIENCE

UNEQUALED PRODUCTION

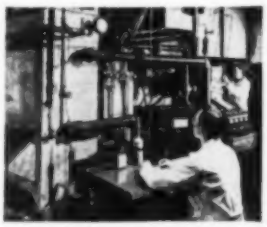
When you specify Aerofin finned heat-transfer surface, you specify high efficiency, long life and easy maintenance. As pioneer in the field, Aerofin has developed unequaled know-how and production facilities to apply to your particular heat-transfer application. Attention to the many details that make up the completed unit typifies the Aerofin way.

Continual research accounts for the accuracy of Aerofin's published ratings. You can use them with full confidence.

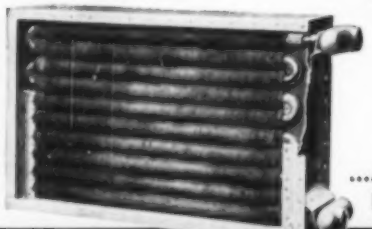


Aerofin manufactures finned heat-transfer surface exclusively. The experience gained by such specialization permits the selection of just the right surface and materials for each particular job — for each application.

Throughout the **CHEMICAL** *Industry-*



Aerofin controls every phase in the production of its finned heat-transfer coils and units. This control is maintained by rigid specifications and inspection, and all assembly is done in the Aerofin plant.



...Aerofin units do the job Better, Faster, Cheaper

AEROFIN CORPORATION 410 South Geddes St. Syracuse 1, N. Y.

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suspended in a current of liquid or gas rising past the particles which differs from a fluidized bed in that an upper level or interface is not formed under conditions of continuous solids entrainment and uniform superficial velocity.

6. "Channelling" is the establishment of flow paths in a bed of solid particles through which a disproportionate quantity of the introduced fluid passes.

7. "Slugging" is a condition in which pockets or bubbles of the supporting fluid grow to the diameter of the containing vessel, and the mass of particles trapped between adjacent pockets moves upward in a piston-like fashion.

LETTER SYMBOLS

Most of the previously established standards† for the fundamental physical magnitudes seem suitable without change. In a few instances, deviation seems advisable or a new symbol seems required through lack of precedent. The following list contains established symbols of special pertinence to the field of fluidization as well as the new ones recommended. New symbols or elements are indicated by an asterisk in parentheses.

Magnitude	Symbol	Typical Units, English System
Area	A	sq.ft.
Density	ρ	lb./cu.ft
Diameter	D	ft.
Diameter, particle (Method of measurement must be specified)	D_p(*)	ft.
Distance above datum plane	Z	ft.
Drag coefficient	C	Dimensionless.
Efficiency, fluidization	φ	Dimensionless.
Energy dissipation, rate	P	(ft.) (lb.force)/sec.
Expansion ratio	N_F(*)	Dimensionless.
Flow rate, mass	w	lb./sec.
Friction factor	f	Dimensionless.
Frictional resistance	F	(ft.) (lb. force)/lb. mass.
Gravity (Newton's Law conversion factor)	g_c	(lb.) (ft.)/(sec.)² (lb.force).
Gravity, acceleration	g	(ft./sec.)/sec.
Length of height	L	ft.
Pressure drop	Δp	lb./sq.ft.
Radius, hydraulic	R_H	ft.
Reynolds number	N_{Re}	Dimensionless.
Shape factor	σ_s(*)	Dimensionless.
Surface, per unit mass (of solids*)	s	sq.ft./lb.
Surface per unit volume	a	sq.ft./cu.ft.
Velocity	u(*)	ft./sec.
Velocity, mass, superficial	G	lb./(sec.) (sq ft.)
Velocity, superficial	u_0(*)	ft./sec.
Velocity, terminal (method of measurement must be specified)	u_t(*)	ft./sec.
Viscosity	μ	lb./sec.ft.
Void, fraction	ϵ(*)	Dimensionless.
Volume	V	cu.ft.

† American Standards, 210.12-1946 (1946); Chem. Eng., *54*, 112 (1947).

While these symbols are fundamental to many physical operations, frequently it may be necessary to apply them to the characteristic states of fluidization systems. The following

(Continued)

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PROVIDE AVAILABLE ACIDITY, METALLIC AND FLUORIDE IONS FOR CHEMICAL PROCESSING USES

...SUCH AS POLYMERIZING

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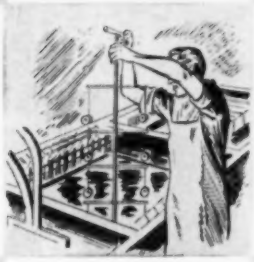

...ELECTROPLATING, FOR COATING OR ELECTROLYTIC PURIFICATION

...LAUNDRY SOURS AND MOTHPROOFING

AND CONCRETE HARDENING AND SURFACE CONDITIONING

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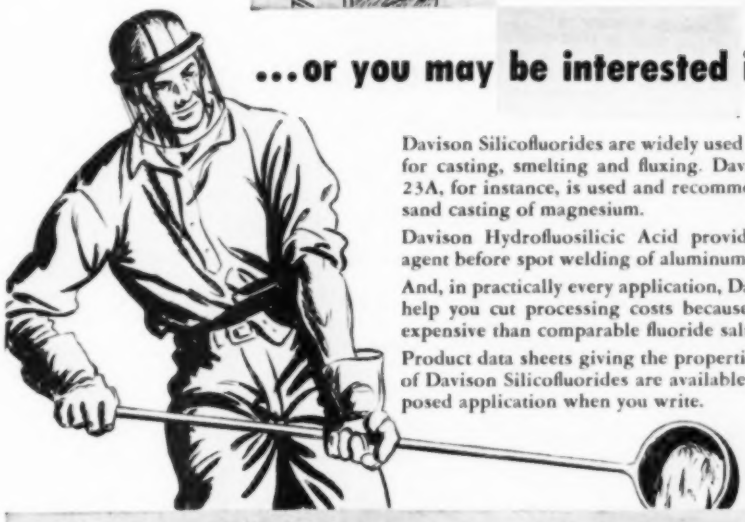

Davison Silicofluorides are widely used in light metal metallurgy for casting, smelting and fluxing. Davison Casting Compound 23A, for instance, is used and recommended as an inhibitor for sand casting of magnesium.

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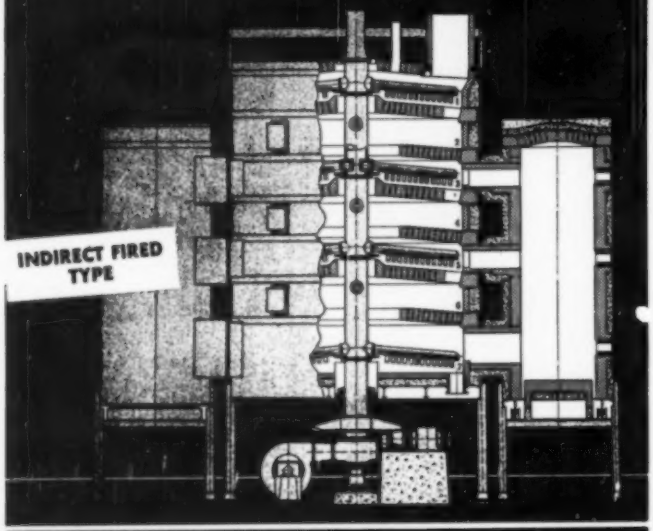

Indirect fired multiple hearth furnace—one of the many modifications of the Nichols Herreshoff and Bethlehem Wedge Roasters.

This type furnace is particularly efficient where special applications require that burner flames do not impinge upon the materials processed through the furnace. Insures a furnace product uniformily processed. This type of construction is also an advantage when processing at relatively low temperatures.

By burning fuel in the combustion towers, complete combustion of the fuel and simpler and better control of the composition of the gases of combustion are possible.

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subscripts are suggested as modifiers for the primary symbols:

a—hypothetical bed with zero interstitial voids.
s—settled bed (conditions of settling must be specified).
f—fluidized bed.
mf—minimum fluidized bed.
e—expanding bed (between s and mf).
d—dispersed suspension.
M—total mixture, solid plus supporting fluid.
S—solid constituent.
F—supporting fluid.
p—individual particle.

Such subscripts are obviously applicable, for example, to symbols L, G, a, and p. To illustrate, L = height of bed (general), L_a = height of hypothetical bed at no interstitial voids, L_s = height of settled bed under specified settling conditions, L_f = height of fluidized bed, p_b = bulk density of the individual particle, including occlusions, p_s = true density of solid constituent, a_M = surface per unit volume of bed, a_p = surface per unit volume of particles, etc.

While these terms are recommended after careful consideration of all viewpoints expressed during their development, the immature state of knowledge in the field of fluidization may make subsequent alteration advisable. If the majority of these terms afford a satisfactory base from which a permanent notation can evolve as knowledge of the field grows, the objectives of this effort will have been achieved. —*End*

READERS' VIEWS AND COMMENTS

King Is Badgered

To the Editor:

Sir:—I believe you have overlooked something in your March issue.

On p. 108, the middle flow diagram shows a process in which various materials are added and absolutely nothing is taken out. One can reach two conclusions:

(1) The apparatus is made of some new type of rubber which can expand indefinitely, or,

(2) A method has been found for the destruction of matter.

In either case, the process is worth more publicity than you have given to it.

W. L. Badger
Consulting Chemical Engineer
Ann Arbor, Mich.

King out of Check

To the Editor:

Sir:—We accept Mr. Badger's observations on the flowsheet. There should have been an arrow showing that the treated liquid did leave the process.

(*Continued*)

CORNING MULTIFORM GLASS

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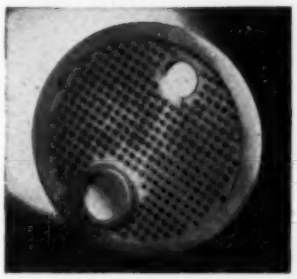

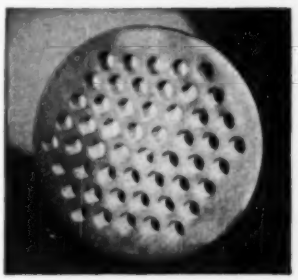

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You can use Corning MULTIFORM Glass in any of the processes for which either PYREX brand laboratory ware or glass pipe is used. It safeguards product purity, extends service life, remains easy to clean, and is relatively inexpensive. It is frequently used as bubble caps in columns, as crucibles, in vacuum pumps, steam ejectors, etc. For further information write Corning.

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This liquor, of course, goes to the effluent treatment plant and is absorbed there.

There is a far more serious error in the article, but which Mr. Badger was kind enough not to mention. In the flowsheet having to do with the manufacture of sodium nitrite, there are two misprints where the word "nitrite" is spelled "nitrate," the description made in the paragraph on this subject makes it perfectly clear. We regret the misspelling. It is a very common error, but we wish it had been caught.

We can assure Mr. Badger that we have no type of rubber which can expand indefinitely nor a method for the destruction of matter, but that we are complimented by the fact that our article was read by so distinguished a member of our profession.

V. L. King

Calco Chemical Division
American Cyanamid Co.
Bound Brook, N. J.

Spiral Principles

To the Editor:

Sir:—In December 1948 *Chemical Engineering* (p. 104), an article by T. R. Olive on International's Noralyn plant has a statement to the effect that the principle of operation of Humphreys spirals is "somewhat obscure." Evidently the reference cited does not clear up the obscurity.

Actually the spirals (in my opinion) represent the nearest approach to the theoretical aspects of fluid film concentrators of any of the commercial devices known to me. While it is true that we cannot tie down the variables in a quantitative manner for the spirals, neither can we do so for tables or other like devices. Nevertheless, the "principles" of operation appear to be quite evident, in fact, in remarkable harmony with expectations.

G. W. Gleeson

Oregon State College
Corvallis, Ore.

CORRECTION

Convention Paper Abstracts

The item on detergents which appears on p. 246 of the April 1949 issue of *Chemical Engineering* was incorrectly attributed. This paper, which foresaw the annual consumption of a billion pounds of synthetic detergents (dilute basis) within a few years, was presented by Dr. Arthur B. Hersberger, manager, and Dr. C. P. Neidig of the chemical products division, Atlantic Refining Co., Philadelphia, Pa.

—*End*

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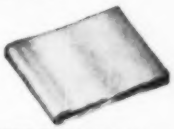
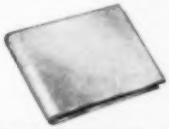


FLATTENING TEST protects you against the possibility of O.D. defects. Specimen is flattened between parallel plates until distance between plates is 3 times the tube's wall thickness. Any sign of cracking or flaws is cause for rejection.



TRANSVERSE BEND is used to double-check the I.D. structure of Carpenter Stainless Tubing. Sample is slit longitudinally and then bent as in the flattening test, but in the opposite direction.

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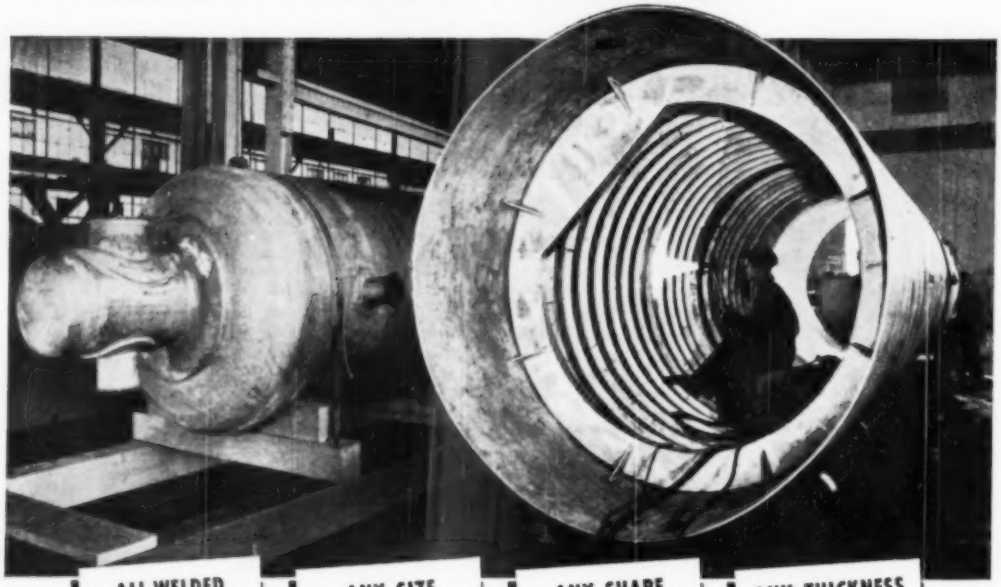

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News From Abroad

SPECIAL CORRESPONDENCE

Reds get new oil boss . . . Synthetic rubber worries the Dutch . . . Italy builds new pipeline . . . Drug unit for India . . . Britain speeds decontrols

Red Shake-Up Hits Fuel Industry

Moscow—The Soviet Government, by decree, has ordered all ministries concerned with the production and processing of oil, and the manufacture of artificial fuel and gas, merged under one central department. Five separate ministries are affected. The new department, to be known as the ministry of the oil industry, will be under the direction of Nikolai Konstantinovich Baibakov.

Dutch Want Synthetic Rubber Output Cut

Amsterdam—The Dutch delegation to the conference of the International Rubber Study Group, which began in London on March 28, is advocating the alleviation of the American regulations concerning obligatory use of synthetic rubber. They hold that the present rubber price in Indonesia (19¢ per lb.) is much too low compared with other commodities: since 1938 rubber has risen only 40 percent, other commodities 150 percent in the aggregate. The United States, they allege, is "synthetically" depressing the rubber price and is prohibiting supply and demand from having their free course. Without obligatory rules, they hold, all American tire manufacturers would use only natural rubber. A higher rubber price would mean little to the tire manufacturer, since it makes up only a fraction of the costs. American synthetic output should therefore be cut from 400,000 to 150,000 tons.

Italy Builds New Pipeline To Move Oil to Sea

Vado Ligure—The new Italian concern formed by the Fiat Co. of Turin and Caltex Oil Products Co. of New York has just begun construction of the pipeline connecting the port of Vado Ligure (Savona) to Trecate (Novara), and of the new oil refinery at Trecate. A coasting station including 51 tanks with a total capacity of 50,000 tons is being erected at Vado Ligure. The Trecate refinery is to have a total crude charging capacity of 2 million tons yearly. Both works, financed with ERP funds, are to be set into operation within 1950.

The Vado Ligure-Trecate pipeline is to be built underground with steel pipes of 500 mm. diameter, with a capacity of 1,200 liters per hour and a pumping station at 126 meters above sea level, the highest point reached by the line.

The Trecate refinery is being erected along the coast of the river Ticino, by which it will be possible to ship oil and petroleum products to Locarno, Switzerland, by inland waterways. The new refinery will produce high octane gas, kerosene, gas oil and lubricating oil. Distribution of the refined products in Italy is to be handled by a new Italo-American company.

Argentine Tannin Unit Is Shut Down

Buenos Aires—The largest quebracho processing (tannin) company in the world, El Forestal, has shut down operations due to the lack of market for its product. Some 6,000 workers are affected.

It is now believed that stocks of quebracho extract, used for tanning leather, now amount to over $20 million worth in Argentine warehouses. Exports have been very light over the past two years due to the high prices charged by the Argentine state trading monopoly, IAPI, and by the fact that new chemical tanning agents have been put on the market recently.

However, the recent removal of the head of IAPI and one-time economic czar of Argentina, Sr. Miguel Miranda, may shortly bring Argentine quebracho back into a competitive selling position with considerably lower prices. In case markets are recaptured, it is presumed El Forestal would resume operations. Argentina and Paraguay are peculiarly favored with the quebracho tree from which the extract is made. Paraguay sells its quebracho wood to Argentina for processing.

India to Erect Drug Plant in Near Future

Bombay—Design and construction of the long-discussed penicillin and anti-malarial factory in Bombay finally has been entrusted to the Swedish firm of Karnbolaget by the Indian government. The plant is expected to take three years to construct and to cost roughly $6 million when finished.

The agreement is reported to call for the following annual capacities:

Penicillin: 1,200 million oxford units	
Anti-malarials:	100,000 lb.
Sulphameraline:	60,000 lb.
Sulphathiazole:	20,000 lb.
Sulphanilamide:	20,000 lb.

When completed the plant is to be run by Indian nationals, trained during the construction period.

Old Mine Is New Oil Depot in Sweden

Stockholm—A unique oil depot was recently taken into service by the Swedish Board of Roads and Waterways. Not far from Stockholm, two old feldspar mines have been converted into underground oil tanks with an aggregate capacity of 160,000 cubic meters, or about 14 normal tanker cargoes of oil. The oil which is pumped direct from the tank ships into the mine rests on some feet of salt water and can be "skimmed off" down to half an inch from the salt water level. To maintain a suitable degree of viscosity of the oil, a 450-meter copper heating coil has been installed in the

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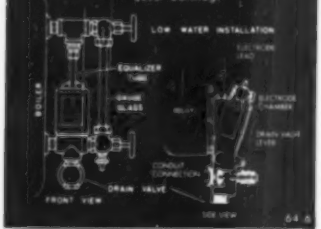

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previous galleries of the mine. Besides being very cheap in construction, the new depot is considered to be practically atom-bomb-proof.

Animal Sleeping Sickness Headed for Extinction

LONDON—Imperial Chemical Industries of Britain is planning to produce between two and three tons of antrycide—the new drug for combatting deadly trypanosomiasis in animals—during the coming year. This is enough to cure or immunize approximately 2,000,000 animals. First shipments will be made to the Sudan, Kenya, and Uganda.

Through antrycide, discovery of which was announced last December, British scientists are confident that trypanosomiasis—caused by the tsetse fly and known in its human form as sleeping sickness—can be eliminated. If this can be accomplished, it means that 4,500,000 sq. mi. of African grazing land now can be made safe for cattle raising.

Principal advantage of antrycide, a white crystalline powder soluble in water, is the fact that it can be administered by any farmer, and the presence of a skilled veterinarian is unnecessary.

The new drug is the discovery of a team of ICI chemists and biologists, headed by the late Dr. F.H.S. Curd and Dr. D. G. Davey. Experts from the British Colonial Office were members of the team that carried on the successful experiments in South Africa.

Dr. Curd and Dr. Davey first tackled the problem of finding a remedy for trypanosomiasis in animals in 1944. Many synthetic compounds likely to be effective against the parasites in the blood stream that cause the disease were tried before it was discovered that antrycide would cure all forms of the disease encountered in cattle, horse, camels and other animals.

All laboratory work had to be carried on in Africa because neither the government nor ICI dared risk producing trypanosomiasis in large animals in England even under the strictest of controls. Field labs were established in Khartoum, Nairobi, and Entebbe. Experiments are still being carried on at these posts in order to obtain specific data on the period of immunity following innoculation. When ICI hits its full production of antrycide, distribution of the drug also will be extended to West Africa.

According to David R. Rees-Williams, colonial under-secretary of the Colonial Office now looks forward to a vast expansion of mixed farming in areas of Africa which heretofore have been regarded as precarious or impossible agricultural ventures. It will give the world a new area four times the size of Argentina for the production of meat.

The 39-year-old Dr. Curd did not live to see antrycide publicly acclaimed. The brilliant scientist, who is also credited with a major contribution in the discovery of paludrine, the anti-malarial drug, was killed in an English railway wreck last November.

Because there are more effective drugs, antrycide has not yet been tested against human sleeping sickness.

Petroleum Output in Italy Subject of Study

ROME—In international statistics Italy has always figured as a country with a small output of petroleum. Production amounts to less than 15,000 tons per year, as against total needs for petroleum products which in 1949 will exceed 4,000,000 tons.

As traces of petroleum are found in almost all the mining districts of Italy, from Piedmont to Sicily, prospectors during the past 50 years have been making studies and drilling to find oil beds, guided by surface manifestations.

Prospectors have conducted their work in the Appenines and their foot lands, starting in the North of Salice Terme, Reborbido and S. Colombano in the Province of Pavia, at Podanzano, Montchino and Velleia in the Province of Piacenza, at Fontevivo, Salsomaggiore, Val Parola and Fornova in the Province of Parma. In Central Italy we should mention the search for petroleum at Fiorenzuola and Marradi in the Province of Florence, at Fontespina in the Province of Macerata, at Amendola in the Province of Ascoli Piceno, and in the Pescara Valley in the province of that name.

The companies that have done serious work in this field are the Azienda Generale Italiana Petroli (AGIP), the Societa Petrolifera Italiana (SPI) belonging to the Standard group, and the Societa Petroli d'Italia. The first of these has extended its inquiries all over Italy and has sunk wells that yield moderate quantities of oil at Podenzano, Fonteviva, Rocca Casauria (Pescara) Tramutola and Ripi in Valle Latina.

The second of these companies has restricted its field of operations to North Italy, developing the small oil-beds of Vallezza (Fornovo) and Centopoggi (Salsomaggiore). The third has not gone beyond the zones bordering on the old petroleum wells of

Montechio and Velleia in the Province of Piacenza.

With the exception of Sicily where the search for petroleum has been made not only in tertiary but also in secondary and perhaps even in primary strata, the prospectors who have worked in the areas of the Appenines above mentioned have not gone below the tertiary strata, in which the drilling has tried to pierce a clay formation, characteristic of the upper cretaceous formation. The small results secured are due essentially to the fact that the Appenine formations are broken, often indeed convulsed, unfit for containing any large reservoir of petroleum.

But for the past 20 years students of the oil possibilities of Italy have begun to start from the hypothesis—supported by observations made in Galicia, Roumania and at Grozny, Persia, and elsewhere where the rich oil-beds are found not in the mountains but in the plains—that oil may exist in the great valley of the Po which stretches in front of the chain of the Appenines.

In 1927 the AGIP, while still engaged in prospecting in the mountain areas, began to make geophysical inquiries in the plain, using at first gravimetric systems which did not give any remarkable results. Later on, thanks to the efforts of Engineer Jacobini, who in 1939 sent a party of engineers of the AGIP to the United States to learn on the spot how to use the new machinery, the geoseismic method has been used.

On the strength of the results obtained by geoseismic surveys in 1942 in the plain area, in a zone in which no outward signs of the presence of hydrocarbons existed, drilling was carried out in the vicinity of Lodi, 35 kilometers to the southeast of Milan, and revealed the presence of gas at a high pressure at depth of 1,500 meters in the upper niocene strata.

During the war there was a pause in the explorative works, but in 1946 the AGIP intensified and developed its plans for prospecting in the valley of the Po, and now considerable quantities of gas are obtained from wells sunk near Lode. The gas is used to run some industrial plants in Milan.

In 1947 and 1948 the presence of other wells with high pressure natural gas was ascertained. Quite recently, in the central part of the plain not far from Busseta, a well has been sunk in a structure identified by the geoseismic method, and at a depth of some 1,500 meters gas was found and at 1,600 meters a stratum was reached containing petroleum.

Particulars about this discovery have not yet been published and evidently one well is not enough to enable the engineers to determine the volume of

(Continued)

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oil contained in the strata reached. But the importance of this discovery is great, because it may well be that in all the structures buried under the plain lands of the valley of the Po there is not only gas but at a greater depth petroleum also. This discovery has greatly encouraged those here who hope in the course of a few years Italy also may become an oil producing country.

India Wants to Push Soap Exports

Bombay—Pleading for a more liberal export policy, the All-India Soap Makers' Association has revealed that of its 250,000 long ton manufacturing capacity only 130,000 long tons are consumed annually in India. This indicates that the per capita annual consumption is on the order of 1 lb. compared with an estimated 20 lb. in the U. S.

Monsanto Expands In British Columbia

Vancouver – Monsanto (Canada) Ltd. has started construction of a resin-glue factory on the Fraser River near Marpole, B. C. The plant will cost $190,000.

This is the second unit of a large-scale expansion program. A $100,000 first unit was recently completed. It includes a resin-scaler plant, tank farm and boiler plant.

Additional projects will include wall-coating and dry products plants. The company will continue operation of the soybean, casein glue and wall products plant on Granville Island.

Northern Construction Co. and J. W. Stewart Ltd., have the contract for the new plant. Included is installation of a sewer for the new plant and a 1,400-ft. steel fence around the buildings.

The new factory will be one and three story construction. Main portion, 64 by 75 ft., will be concrete block. The second section will be structural steel and asbestos sheeting with flat tar and gravel roof.

A truck and rail loading platform will be built. B. C. Electric Railway Co. ran a spur to the new development last year.

Monsanto Chemical Co., absorbed L. F. Laucks Ltd. with a plant on Granville Island, in March 1944. Laucks Ltd. was operated as a subsidiary. In 1948 Monsanto (Canada) Ltd. was incorporated. The Canadian company has plants at Vancouver and Montreal and a sales office at Toronto.

A research staff of 15 persons is

(Continued)

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With its consolidation as part of the Honeywell organization, the Belfield Valve Division gains new engineering and service facilities which will be reflected in additional benefits for you.

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Series 700 . . . for wide-band proportioning control.
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#501A . . . pilot piston type for small or "pilot" flows.

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HYDRAULIC MATERIAL HANDLER

Smoothly dumps Liquids, Solids, Semi-Solids to any height or level

Designed to save time, labor and costly handling—the new LEE Hydraulic Material Handler is available in a wide range of standard and special sizes to fit any specific job application. Operates from ordinary city water pressure—*requires no electrical connections, portable or stationary* as the installation requires.

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LEE METAL PRODUCTS CO. INC.

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ALL LEE KETTLES ARE MADE TO A.S.M.E. CODE

maintained by the Vancouver branch and the company has benefit of six large research laboratories maintained by the U. S. company. Local researchers are developing new products and new uses for old products.

More Chemicals Decontrolled in Britain As Supply Situation Eases

Slow improvement of supplies in the face of heavy calls from home consumers and brisk demand in the export market is the dominating feature in the British chemical trade. With the bulk of requirements met under long-term contracts, marginal offerings and demands tend to exercise a large influence on the appearance of the spot market, but for most chemicals, supply and demand are better balanced than at any other time since the war. The pressure of demand is easier even for commodities like alkalis, and there are more spot parcels on offer for purchasing outside contracts.

Therefore the Board of Trade has scrapped quantitative control restrictions on a number of important chemicals. Included are borax and boric acid, calcium chloride, caustic soda, furfural, oxalic acid, rennet casein, titanium dioxide, urea, and white lead. The voluntary control of freon gas and vermiculite has ended, and pine oil and rosin, tanning materials, and butyl and GR-S synthetic rubbers have reverted from public to private purchase. The important quotas for North American asphalt were removed some time ago, a relaxation which was announced by the Board of Trade now, together with the new relaxation measures.

Decontrol of these commodities has been welcomed by the chemical industry as obviating much unproductive form-filling, but the shift in the supply-demand balance which it reflects is of course watched with some misgivings. Supplies continue to increase, but so do important cost elements. The present high cost of plant replacements and extensions will obviously have far-reaching repercussions on profits if these new expensive installations cannot be utilized at or near capacity. In the paint trade where the Board of Trade requested manufacturers to lower their prices, reviving competition resulted in price cuts exceed-

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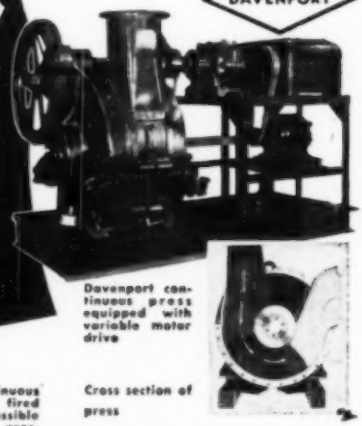
Pressing and Drying SEMI-SOLIDS

DAVENPORT



Davenport continuous press equipped with variable motor drive

Cross section of press

Davenport continuous presses, continuous screens, rotary steam tube, direct fired and hot air dryers are making it possible for chemical, glucose, starch, food processing, rubber reclaiming plants, packing houses, breweries and distilleries, as well as many allied industries, to extract excess moisture and dry their products at the lowest possible cost.

We design, fabricate, and supervise the installation of complete drying plants. Your absolute satisfaction is guaranteed by the undivided responsibility of a single source of supply.

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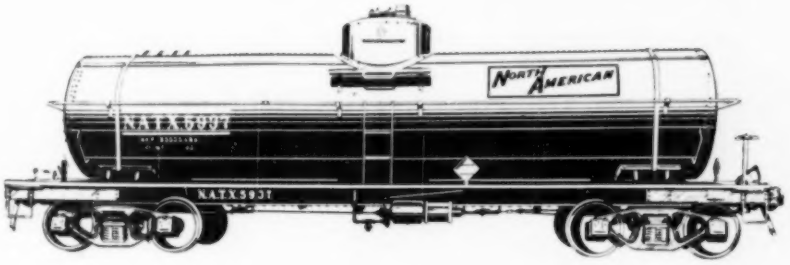
Davenport rotary dryers available in steam tube, direct fired and hot air models.

DAVENPORT Machine and Foundry Co. Davenport Iowa U.S.A.

BUILT TO SERVE
The Chemical Industry



Our modern single and multiple compartment tank cars are designed to protect chemicals in shipment to any market in the nation. This equipment plus our nationwide organization plus years of close cooperation with the chemical industry assures you safe, economical railroad shipping and efficient help in solving your transportation problems. We suggest you consult our representatives at any one of our offices listed below for further information.

NORTH AMERICAN CAR CORPORATION
NORTH WESTERN REFRIGERATOR LINE COMPANY

A nation wide organization with branch offices in important market centers

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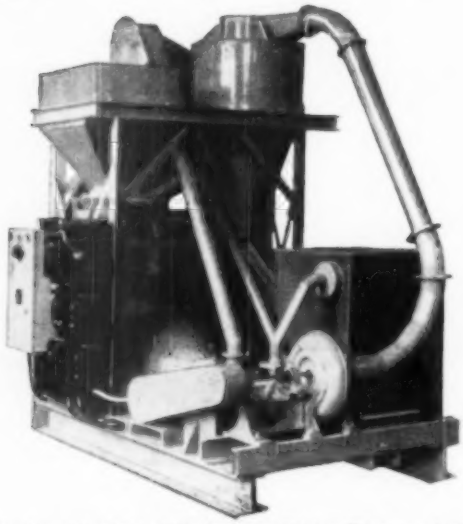
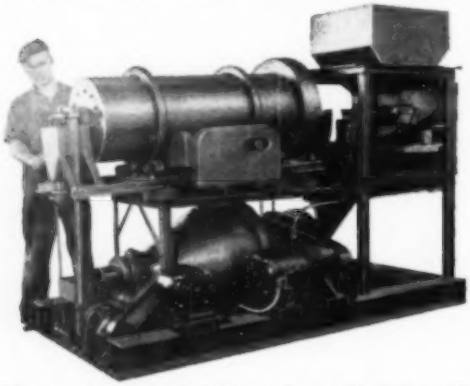
"PACKAGED"
Grinding Systems



Standing only 8' high, the Hardinge Dry Grinding Unit is completely self-contained and portable. Needs only electrical connections to be put into operation. Complete with mill, classifier, feeder, "Electric Ear"*, dust and product collectors. Bulletin AH-373-11.



Make power and water connections only, and the Hardinge Wet Grinding Unit is ready to perform. Self-contained and portable, 6½' in height. Includes mill, classifier, pump, launders, feeder and "Electric Ear".* Bulletin AH-373-11.

*Reg. U.S. Pat. Off.

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ing the percentage rate suggested by the authorities.

Government control over the distribution of chemical materials however still covers an extensive field. Licenses are still required for trade in or manufacture of lactic acid and casein, paint, sulphuric acid, and cotton linters. The long list of commodities purchased on government account for resale to manufacturers or consumers in Britain includes basic slag, calcium carbides, casein (lactic and rennet), Chile nitrates, cotton waste, cyanamide, molasses, ethyl alcohol, butyl alcohol, acetic acid and anhydride, phosphate rock and superphosphates, potash, potassium carbonate and caustic potash, sulphur and pyrites. Licenses are still required for cotton linters, linseed oil, molasses, ethyl alcohol, butyl alcohol, acetic acid and anhydride, and wood pulp. For some of these products "open" licenses are being issued now authorizing the holder to buy any amount of the commodity which he requires.

The government is thus still the sole importer of Chile nitrates, rock phosphates and potash salts and also buys and sells the whole British output of basic slag, cyanamide, superphosphates, etc., while the production of other fertilizer materials like ammonium sulphate is distributed by the producers and their associations in close consultation and according to policy directives drafted together with government departments. The other materials for which the government still reserves the sole right of purchase are commodities obtained from abroad. As long as world shortages of these continue, the government feels that the national interest is served best by central buying agencies.

FERTILIZER SUPPLIES NEEDED

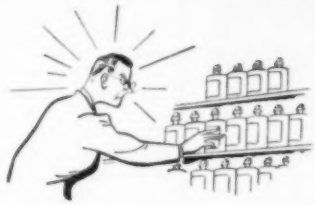
In the case of fertilizer materials the attitude of the British Government has been strengthened by the fact that still bigger supplies are needed. The British fertilizer consumption is now twice to three times the prewar figure. While supplies of phosphatic and potassic materials are more or less adequate, nitrogenous fertilizers are still in short supply and production of them is to be increased further, with a view to meeting the anticipated expansion of requirements in the later part of the 1949/52 economic plan. As regards other fertilizer elements, it is hoped to obtain more potash from Germany and France, more phosphates from North Africa, and more sulphur and pyrites from Italy, Spain and Norway.

The Chancellor of the Exchequer

(Continued)

Use the

Atlas HLB System!



. . . *helps eliminate tedious experiments in selecting emulsifiers*

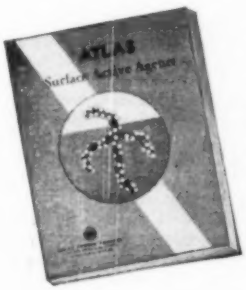
The new Atlas system of choosing emulsifiers is based on empirical numbers representing the Hydrophile-Lipophile Balance (HLB) of emulsifiers. By using this system, you can frequently eliminate many tedious trial-and-error samplings, and quickly find one or two Atlas emulsifiers that fit *your* emulsion problem.

Here are three outstanding features of the system:

1. *A table of HLB numbers* for Atlas emulsifiers enables you to compare affinities of emulsifiers for oil or for water. You can easily calculate HLB numbers for combinations of emulsifiers.

2. *A table of HLB ranges* for various emulsion problems. For example, an HLB range of 12 to 18 is recommended for insecticide emulsion spray oils, 15 to 18 for essential oil solubilizing, and so on. This table also shows which fatty acid derivatives are most favorable.

3. *A systematic procedure* for testing emulsifiers to find the fatty acid derivative and HLB most favorable to your own problem. This procedure helps eliminate wide groups of materials from further research, and determines most favorable *ratios* of emulsifiers in mixtures.



The HLB system—first of its kind—is described in detail in the Atlas Surface Active Agents book. Seventy formulas make the book a handy reference guide in producing various emulsions, polishes, industrial perfumes, insecticides and herbicides, industrial and household cleaning compounds, emulsion cleaners, and many other products.

Write for your copy today on your official stationery.

ATLAS CHEMMUNIQUÉ

Renex Outstanding for Home Laundering*

Now milady doesn't have suds overflowing from her automatic washer, and she'll get superior whiteness and faster rinsing, too, with laundering products made by compounders from Renex detergent. A typical powder is: 15% Renex, 10% water, 25% TSPP, 10% sodium metasilicate, 40% soda ash.

Sorbitol Resists Oral Fermentation

Sorbitol, a natural hexahydric alcohol produced synthetically by Atlas, is widely accepted as a conditioning and sweetening agent in pharmaceuticals such as tablets, mouth washes, gargles, toothpastes and the like. One reason for this acceptance is its relatively good stability and greater resistance to fermentation by oral micro-organisms as compared with sugars.

No Shortage of Sorbitol for Paint

Plentiful supply and downward price trend of sorbitol have influenced resin producers to new evaluation of this material. A 25-page Atlas booklet gives practical directions for making vehicles from sorbitol and from combinations with other polyols, giving exceptional range of control over melting points, viscosities and solubilities of maleic and phenolic modified resin esters.

*Reg. U. S. Pat. Off.

ATLAS INDUSTRIAL CHEMICALS DEPARTMENT

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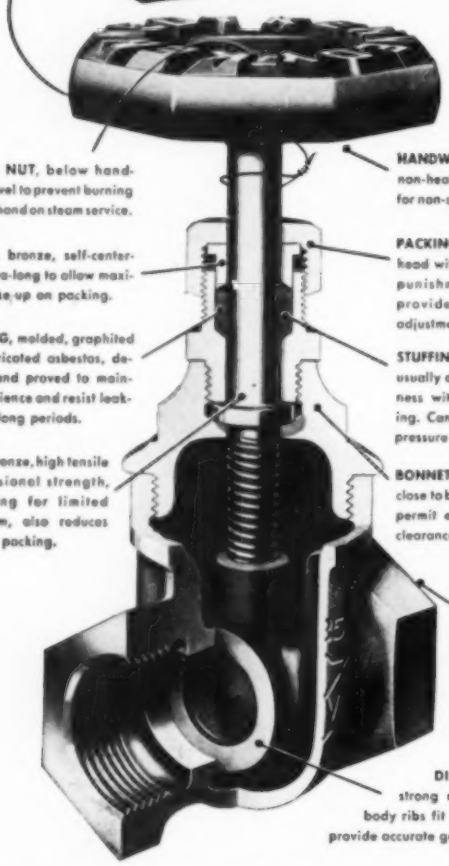
Design and Engineering Put EXTRA Value In This KENNEDY VALVE

KENNEDY STANDARD BRONZE GATE VALVE, FIG. 27, non-rising stem. Conservatively rated for services up to 125 Steam, 175 Water, Oil or Gas. ¼" through 3" sizes available.



WHEEL NUT, below handwheel level to prevent burning palm of hand on steam service.

GLAND, bronze, self-centering, extra-long to allow maximum take up on packing.

PACKING, molded, graphited and lubricated asbestos, designed and proved to maintain resilience and resist leakage for long periods.

STEM, bronze, high tensile and torsional strength, non-rising for limited headroom, also reduces wear on packing.

HANDWHEEL, malleable iron, non-heating design, large size for non-slip, comfortable grip.

PACKING NUT, bronze, heavy head withstands pipe wrench punishment, extra threads provide increased packing adjustment.

STUFFING BOX, bronze, unusually deep to provide tightness without jamming packing. Can be repacked under pressure wide open.

BONNET, bronze, large hexes close to body increase rigidity, permit easier removal when clearances are close.

BODY, bronze, rugged construction, straight passageway minimizes flow resistance, disc clears passageway in full open position.

DISC, bronze, simple, strong mechanism. Interior body ribs fit channels on disc to provide accurate guide.

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has presented his Economic Survey for 1949 from which it appears that industrial investment projects likely to increase substantially exports to hard currency markets or making marked and direct savings in imports from hard currency sources will receive special consideration from the government. Of chemical products petroleum chemicals, carbon black and calcium carbide are certain to receive consideration under the first heading and coal-tar derivatives, which enjoy a big export market in the United States, under the second. In addition, chemical plant investments will also be encouraged as needed to overcome shortages of alkalis, sulphuric acid, and dyestuffs intermediates. Money is also needed to develop technical advances in the field of synthetic fibers and plastics. The chancellor's review showed to what extent the government's attitude to all industries, including the chemical trades, is ruled by the wish to close the dollar gap before ERP ends.

PRODUCTION STEP-UP

Chemical manufacturers have studied the economic survey with special care to discover in what directions they will have to step up their production most. Particular interest has been aroused by the target of 300,000,000 lb. of rayon for the current year, compared with an actual output of 148,000,000 lb. of continuous filament and 86,000,000 lb. of staple fiber in 1948. New production units and extensions to existing rayon plants are not expected to become effective before the later months of 1949, but when they do come into operation the chemical industry will be called upon to supply substantially larger quantities of various products. As other home producers cannot be denuded of supplies, this may involve cutting-down of exports of certain types of chemicals. By the end of this year there will also be more nylon available for British home consumption, and the plans for the manufacture of an entirely new fiber (Ardil) from groundnut shell are also making progress; official approval has been obtained for extensions to a factory at Drungans, Scotland, in this connection.

Substantial additions are to be made this year also to the coke-oven and by-product industry. On coke ovens alone £26,400,000 will be spent in 1949, compared with £16,400,000 in 1948 and £14,000,000 in 1947. The new plant installed in the past two years mostly replaced obsolete plant incapable of continued operation and did little to add to the industry's capacity.

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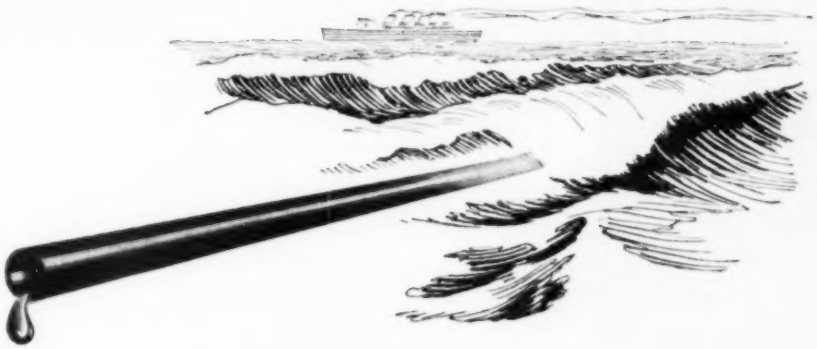

WHERE SEA WATER IS APPLICABLE FOR COOLING IN STEAM CONDENSERS

Admiralty condenser tubes (both plain and finned)—made by Wolverine—have shown very satisfactory resistance to the corrosive conditions encountered in heat exchangers in oil refineries where sea water was being used.

THESE ARE THE CHEMICAL AND PHYSICAL CHARACTERISTICS OF ADMIRALTY

Cu.	70.0% min.	P.	.02—.10%	Density—lbs. per cu. in.	0.308
Sn.	.90—1.20%	As.	.02—.10%	Specific gravity	8.53
Pb.	0.075% max.	Zn.	Remainder	Thermal conductivity	0.26
Fe.	0.06% max.			Coefficient of Expansion	2.02

Available in Outside Diameters from ⅛" to 2" and in wall thicknesses .049"—.134"

Wolverine Condenser Tubes are also available in Cupro-Nickel, Aluminum, Brass and Copper base alloys.

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MANUFACTURERS OF SEAMLESS NON-FERROUS TUBING
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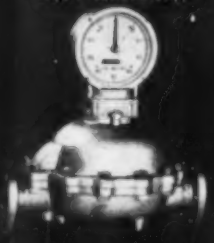
Good News

CORROSION-RESISTANT

LIQUID METERS

Now Available



with NIAGARA CHEMICAL METERS

The same reliable measurement of liquids that has characterized Niagara Volumetric Liquid Meters for over 50 years is now being made available in a new line of NIAGARA Chemical Meters. Since all internal parts of the new Niagara Meters are of No. 316 stainless steel — except the special-type measuring piston — a wide range of corrosive liquids can be metered, with minimum maintenance requirements. Corrosive products such as caustic soda, most acids, molten sulphur can be measured, provided they are metered free from air.

The new Niagara Stainless Steel Chemical Meter is made in sizes 1" DV and 2" GV with capacities from 3 to 160 GPM.

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Please send me full information on use of your new Niagara Chemical Meter for:

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BUFFALO, N. Y.

FOREIGN NEWS, *cont.* . . .

Many more coke ovens will therefore be required, and the 1949 additions represent only the first stage of a long-term program in which the Iron and Steel Board, in addition to the National Coal Board and the gas industry, now in course of nationalization, is interested. It is realized that the coke-oven and coal-tar industries have to make a very important contribution to the supply of heavy chemicals, but little seems to have been done yet to coordinate the plans of the state-owned coke-oven works with those of the mostly privately-owned tar distilleries.

More Ethyl Alcohol From Sulphite Waste in Canada

Ottawa — Commercial Alcohols Ltd., has commenced operations in the largest plant of its kind in the world at Gatineau near Ottawa to produce ethyl alcohol from sulphite liquor, a by-product of the pulp-making processes of Canadian International Paper Co. at a distance of only a couple of hundred yards from the new plant, with the estimated cost of the new plant being approximately $2,750,000 and involving an annual exchange saving of about $2 million since raw materials, molasses, were generally imported for such operations in the past. Such imports are now unnecessary under the new chemical process employed in this new plant.

The actual process of producing alcohol from sulphite liquor is not new, this largest plant of its kind in the world will make from two to two-and-a-half million imperial gallons each year. The new plant is located near the Canadian International Paper Co. plant.

The new plant's construction was started late in 1947 and it has been completed pretty close to schedule, being built by Anglin-Norcross Co., with Surveyor, Nenniger & Chenevert as consulting engineers. The planning and supervision of the chemical process has been accomplished by Vickers Vulcan Process Engineering Co., a Canadian company organized by Canadian Vickers Ltd., and Vulcan Copper & Supply Co., of Cincinnati. The general manager of Vickers Vulcan is W. H. Stark, a Ph.D. in biochemistry and bacteriology from the University of Wisconsin and formerly director of research with Jos. Seagram & Sons Inc., of Louisville, Ky. Vulcan dealt with the design and installation of the process equipment and Vickers did the con-

(Continued)

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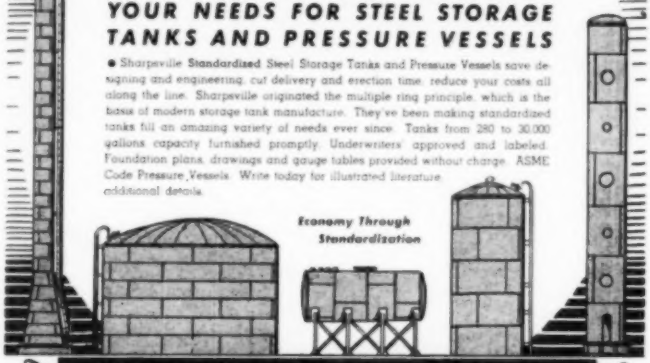
TO SAVE TIME AND MONEY ON YOUR NEEDS FOR STEEL STORAGE TANKS AND PRESSURE VESSELS

● Sharpsville Standardized Steel Storage Tanks and Pressure Vessels save designing and engineering, cut delivery and erection time, reduce your costs all along the line. Sharpsville originated the multiple ring principle, which is the basis of modern storage tank manufacture. They've been making standardized tanks fill an amazing variety of needs ever since. Tanks from 280 to 30,000 gallons capacity furnished promptly. Underwriters' approved and labeled. Foundation plans, drawings and gauge tables provided without charge. ASME Code Pressure Vessels. Write today for illustrated literature, additional details.



SHARPSVILLE Steel FABRICATORS

Established 1840 Incorporated 1907

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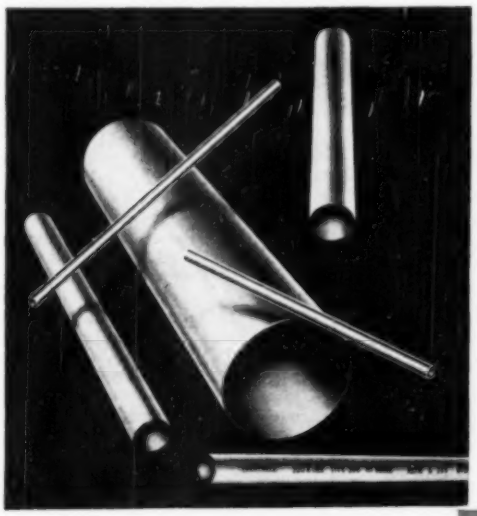
Also Fabricators and erectors of Field Storage Tanks, Stacks, Bins, Large Diameter Pipe and Miscellaneous Steel Plate Work

free reins for your imagination



If stainless steel tubing can solve your problem, then Trent Tubing is your answer—for Trent is *the only mill in the country* with facilities for making stainless steel tubing in sizes ranging from $\frac{1}{8}$" O. D. to 30" O. D. and with wall thicknesses varying from 0.005" to 0.172".

Think what this means to you! Between these limits lies a designer's paradise — a complete range of sizes, finishes and analyses to meet every product and process need. PLUS engineering and metallurgical assistance for the one application in a thousand that falls outside of Trent's normal production.

Yes, when you plan with Trent you can give free rein to your imagination — you may design for corrosion, heat, abrasion, or simply sanitation, with the knowledge that your precise requirements can be met. Your inquiries on Stainless Steel, Inconel, or Monel Tubing will be welcomed. Ask for the Trent Data Bulletin and indicate the application you have in mind.

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STAINLESS STEEL TUBING

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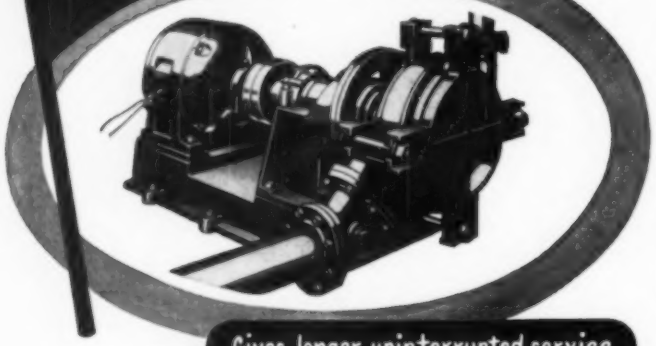
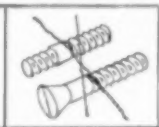
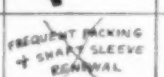
Helps avoid your biggest pump problems
Morris Type "R" Slurry Pump



Gives longer uninterrupted service

Ordinarily harsh abrasives wear out your pump. The corrosive action of acids eats away its utility. Time-consuming maintenance and repairs cut down your production. Now see why the Morris Type "R" helps avoid these problems.

1		**Simple design**—The Morris Type "R" has no internal studs and bolts. Nor does it have troublesome internal joints and fits. The Suction Disc Liner is merely clamped into position between disc and shell. *Fewer wearing parts means less maintenance and longer uninterrupted service.*
2		**Easily dismantled**—The impeller and shaft sleeve of the Morris Type "R" Slurry Pump can be renewed without *disturbing* the suction and discharge piping or the bearings. This means considerably less lay-up time.
3		**More abrasive resistant**—With the clamping effect of the bolts on the discs, the shell is not subject to high stress. Consequently, the shell can be made of a large variety of materials, including those of high abrasive resistance. Yet these materials need not necessarily be of high tensile strength.
4		The hydraulic passages of the suction disc are extremely large and velocities are low. As a result, wear is minimized and renewal infrequent.
5		**Stuffing box troubles are practically eliminated** because the suction gland is under low suction pressure only.

IN CHEMICAL ENGINEERING—Morris Type "R" Slurry Pump handles mixtures containing ore concentrates . . . tailings slag and residue from filters and classifiers . . . all types of caustic or acid mixtures containing abrasives or solids.

MORRIS Type "R" SLURRY PUMP

More easily maintained . . . more easily dismantled . . . more hours of continuous service. Proved by 84 years' Morris experience in pump building.

MORRIS CENTRIFUGAL PUMPS
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struction work in regard to stills, tanks, pipelines, etc. The vapor re-use system, in which the progressively purer alcohol passes through six different five-story-high stills, is used in this new plant and it is a patented process of Vulcan. It is said to have great economy in heat by a combination of pressure and vacuum stills.

Italians to Place Refinery Equipment Orders Here

Milan—Orders for oil refining machinery are to be placed in the United States by the Italian subsidiary of the Royal Dutch-Shell group. The Italian Government has granted them a concession to build an oil refining unit with a crude oil charging capacity of 2.5 million tons annually at La Spezia.

Water Shipping Studied in Canada as Rail Rates Jump

Ottawa–Canadian railways are increasing their freight rates on a large number of commodities moving from the eastern areas of Canada to the West Coast in the so-called "competitive" category of shipments which require no permission from the Board of Transport Commissioners in Ottawa. An announcement has been made by general steamship agents that an all-water service started between Montreal in the east and Vancouver on the West Coast on about April 25. A "steamship pool-car" service was tied in with the new all-water service covering commodities such as chemicals. No intermediate stops are planned.

As a result, keen competition, if not an ultimate price war, is expected when the steamship service gets going in direct competition to the railways. More favorable all-water rates and more vessels are predicted within a short time, with resultant benefits for shippers of chemicals and certain other products.

Northwest Gas Reports on Pipeline Plans

Vancouver—Development of a pipeline system to serve the Pacific Northwest with Alberta gas was outlined recently by James Walker of Edmonton, representative of the Northwest Natural Gas Co.

Mr. Walker said the pipeline system would be a stable industry, and suggested that resulting increases in provincial revenues could mean new

(Continued)

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Secondary Butyl Acetate—$CH_3COOCHCH_3(C_2H_5)$
Isopropyl Ether—$C_3H_7OC_3H_7$
Methyl Ethyl Ketone—$CH_3COC_2H_5$

ENJAY HYDROCARBONS

Butadiene—$CH_2{:}CHCH{:}CH_2$
Isobutylene—$CH_2{:}C(CH_3)_2$
Diisobutylene—$CH_2{:}C(CH_3)CH_2C(CH_3)_3$†
Triisobutylene—$CH_2{:}C(CH_3)CH_2C(CH_3)_2CH_2C(CH_3)_3$†
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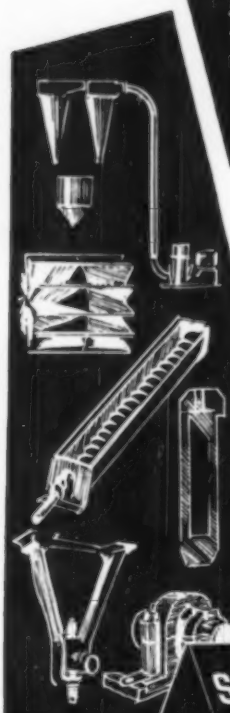

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72

and better roads, improved educational facilities and other developments for the benefit of Albertans generally.

"The province has waited many years for a market for its resources. It has long desired to sell its coal. It is now selling its petroleum to areas outside the province. It would seem entirely consistent with this desire and policy to sell natural gas to outside areas," Mr. Walker said.

He dealt extensively with the whole question of gas export and outlined the plans of Northwest Natural Gas for its 1,700-mile pipeline to the Pacific northwest of the United States and Canada.

Estimated cost of constructing the pipeline is $100,000,000, of which about $40,000,000 would be spent on the part of the line in Canada. Around $16,000,000 would be spent for labor in Alberta. A Canadian corporation would be formed to construct, own and operate the part of the system in Canada, and Canadians would be given the opportunity to invest.

"The project," he said, "will be one of Alberta's largest industries. It will exceed any other company in capital investment and will rank among the first 12 in payrolls and the first 6 in cost of materials."

Natural gasoline, propane and butane would be extracted from the gas before export. Propane and butane, if recovered in large amounts, should form the basis of new industries in Alberta. The propane could be used as bottled gas for fuel in rural areas. Both propane and butane would be available for the manufacture of synthetics like nylon and rubber.

In addition, Northwest has been approached about the possibilities of extracting sulphur from the gas for chemical industry purposes. A plant capable of producing 300 tons of sulphur a day is projected.

Mr. Walker also dealt with the extent of Alberta gas reserves, current and estimated future consumption in the province over export and other questions related to the export topic, which was recently aired before the Alberta natural gas commission.

Russians Claim Chemical Industry Is Growing

Moscow—A 32 percent increase in 1948 output as compared with 1947 was registered by the enterprises of the chemical industry of the USSR according to a government announcement. The production program for nitrates, calcined and caustic soda, synthetic dyes, synthetic rubber, automobile

(Continued)

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Thousands and thousands of installations ago, a new system for transmitting power to machines by electricity was introduced without fanfare. Today, after ten years, this Reliance V•S Drive has the respect of management in countless plants in every industry. *It is one of the surest ways to increase production and lower operating costs!*

Reliance V•S, the original *Packaged, All-electric, Adjustable-speed Drive,* will operate direct from your plant's A-c. circuit. Controlled manually or automatically—at the machine or from any remote location—it will provide whatever flexibility is needed to secure maximum output at minimum cost. Quick, smooth starting and stopping and stepless speed changing over an infinite range are basic functions. Maintenance of proper tension on roll-fed materials, reversal at any point and other special functions can be added as desired.

For further information, write today for Bulletin 311. Or, a phone call to the nearest Reliance office will bring a Reliance application engineer to show you where and how you can use V•S most profitably.

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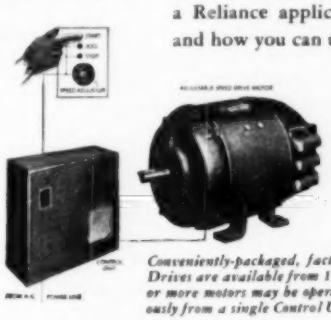

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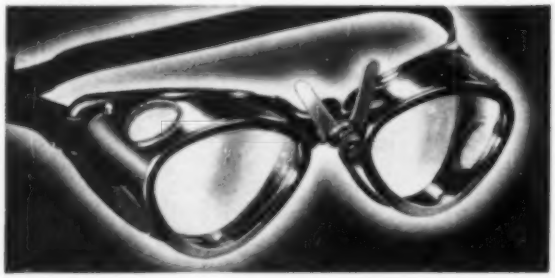

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Extra wide vision is provided by the triangular lens shape, an exclusive WILLSON feature. The adjustable nose bridge and rolled edges of the eyecups assure good fit around the eyes while the adjustable elastic headband is adaptable to all head sizes.

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tires, rubber footwear, plastics and other chemical products and items was exceeded. In 11 months of 1948 the chemical industry reportedly yielded 430 million rubles of accumulations beyond scheduled production. Since 1947 figures were never made public, and since the ruble underwent a value shift in 1948, it is impossible to obtain a true picture of chemical production for the past year other than the official indication that it is up.

Canada Gets New Silicon Carbide Plant

Ottawa—Production at Electro Refractories and Alloys Co. of Canada at the new Cap de la Madeleine plant has started. It is a wholly owned subsidiary of Electro Refractories & Alloys Corp., of Buffalo, N. Y. The plant in Canada represents an investment of $475,000. Quebec was chosen because of the cheap available power. Raw materials will come from Illinois and Ohio. In an electric furnace operation, they will be converted into silicon carbide and shipped to the parent Buffalo plant for use in manufacture. The Shawinigan Power & Water Co., will supply 4,000 hp. of electric power.

Merck Plans Further Expansion in Canada

Ottawa—Merck & Co., Ltd. (Montreal) of Canada has received contractors' tenders for further plant extension at Valleyfield, Que., where a $250,000 addition was completed recently, with an $85,000 reconstruction job having been completed lately at Merck's Montreal plant. The Valleyfield expansion includes four new buildings: Administration and research; sterile techniques; general process; and a machine shop.

Briefs . . .

Rio De Janeiro—Brazil manufactured about one million tires in 1948 and hopes to produce 1,300,000 in 1949, practically meeting domestic needs and leaving some for export. Output has quadrupled since 1940.

Amsterdam—Announcement has been made that Unilever N.V. will establish an oil and soap factory at Makassar on Celebes in Indonesia.

Ottawa—Canadian imports of chemicals and allied products increased to $10,838,000 in October compared with $9,940,000 in the same

(Continued)

1 1897—America's first cars, hand-built and expensive, looked like this. Big questions of the day were—will it run? can I ever afford to buy one? Little thought was given to washing a car.

2 1915—Howell "Red Band" Motors arrived. The electrical horsepower age was already under way. Automobiles, as well as other goods and services, were soon to be better, cheaper.

3 1935—This combination brush and spray was one of many early car-washing devices. It wasn't until 1945 that modern assembly line methods began to be applied to the washing of cars.

NOW, A WASH WHILE YOU WAIT!

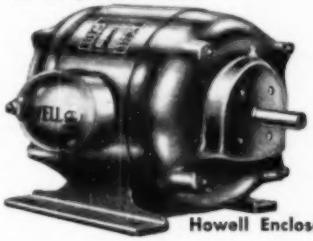
4 Today—Automatic car washers, like this, equipped with nine totally enclosed Howell Motors, turn out a glistening, clean car in a jiffy! Back-breaking labor is gone, valuable time is saved—all so that more people can enjoy better living at less cost.

Working in a shower of water is a tough job for electric motors. But, here again, Howell Motors have made good. These rugged, industrial type motors are an important source of power not only for car washing but also for fans, pumps, conveyors, dairy machines, and all other important industrial jobs.

Are you using Howell Motors? Try them!

Free enterprise encourages mass production, supplies more jobs—provides more goods for more people at less cost.

Howell totally enclosed motor built for operation in high humidity atmosphere. Remember, there's a Howell Motor for *every* industrial job.



Howell Enclosed or Splash-Proof Motor

HOWELL MOTORS

HOWELL ELECTRIC MOTORS CO., HOWELL, MICH.

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If you use process steam you'll want this valuable book—

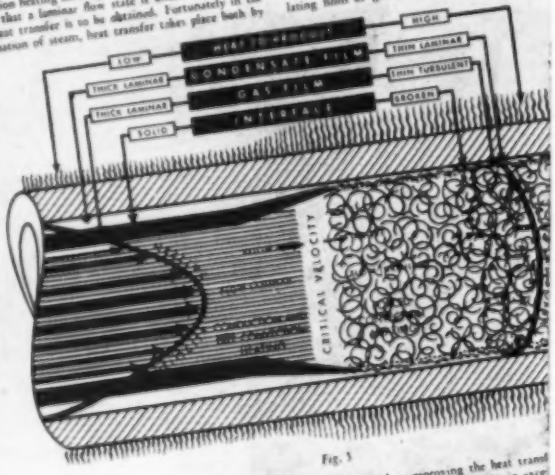

Fig. 3

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FOREIGN NEWS, *cont.* . . .

month a year ago and advanced to a total of $97,497,000 in the first ten months of 1948 as against $94,821,000 last year in the same period the latest report of the Canadian Government reveals.

Vancouver—Western Oxygen Co. Ltd. has purchased property at Cranbrook, B. C., as its site for a $200,000 plant. Development includes construction of a concrete building, 100 by 160 feet, on cement slab foundation, to handle production of liquid oxygen, nitrous oxide, nitrogen and acetylene in containers ready for shipment for industrial and hospital use. K. A. Atkinson is president.

Rio De Janeiro—Newspapers report invention of a machine to crack babassu nuts which would do 50 men's work. It is said to handle nearly 900 lb. per hr., producing about 65 lb. of whole kernels.

Ottawa—The building of two caustic soda plants is contemplated in Chile, according to a report to Foreign Trade of the Canadian Government by E. H. Maguire, Acting Commercial Secretary for Canada in Chile, who states that the production of chemicals in Chile has increased 10.8 percent in the first five months of 1948 compared with the same period of the previous year.

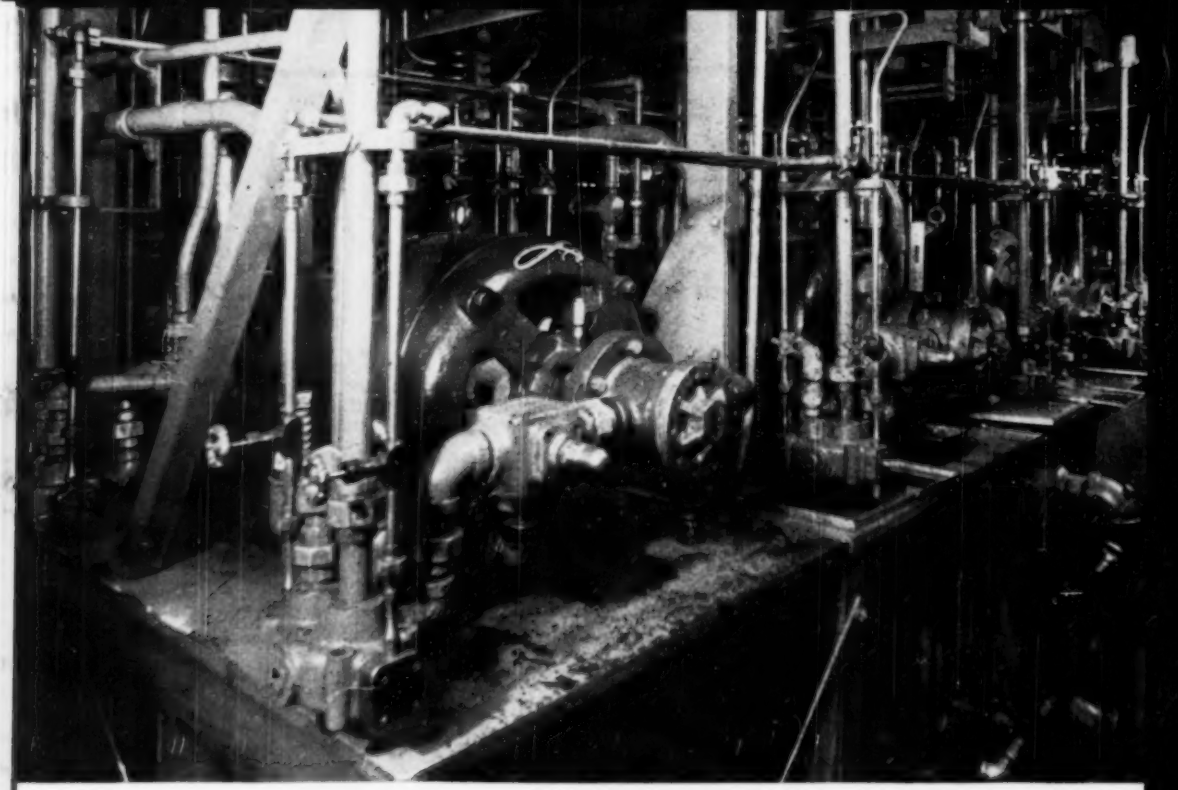
Rio De Janeiro—A French chemist, Joseph Blumenfeld, is to study the possibility of industrializing castor beans in the state of Bahia, at the invitation of the state government. Brazil is by far the biggest supplier of castor beans to the United States. Consideration is being given to exportation of oil rather than beans.

Ottawa—The Canadian Government has relaxed its import restrictions, imposed on account of the serious United States dollar shortage, by removing all import restrictions on paints, varnishes and lacquers.

Amsterdam—A new Royal Dutch synthetic soap (Teepol) factory will go into operation within a few weeks at Pernis, near Rotterdam.

Bombay—A 500,000-gal. power alcohol and methylated spirits factory is under survey by the province of Madhya Bharat, to use the molasses produced by the three sugar factories in the Gwalior area.

Ottawa—Anglo-Newfoundland Development Co. has acquired complete control of the Gaspesia Sulphite Co. by means of a share-for-share exchange offer to Gaspesia minority shareholders.



How to boost the efficiency of your hydraulics

STANOIL
Industrial Oil

A 3,000-gallon central hydraulic system, shown in part above, is used for the operation of 55 molding presses in a midwest manufacturing plant. In 1942, Stanoil 18 was introduced into this large system.

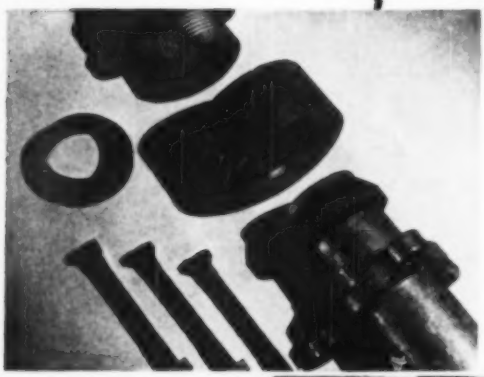
Tests of oil samples, made every six months, showed practically no deterioration of Stanoil. When the oil was changed, after more than 3 years' service, it showed a neutralization number of only 0.53. In the entire 6½ years of operation, make-up oil averaged no more than a barrel per month and there were no deposit or corrosion troubles.

These facts indicate the benefits you can gain by switching your hydraulics to Stanoil, but they by no means tell the full story. This unique, multi-purpose oil will provide clean, dependable lubrication in a wide variety of circulating systems. You can replace costly special oils and simplify stocking problems by using Stanoil throughout your plant. A Standard Oil Lubrication Engineer will be glad to help you.

Standard Oil Company (Indiana), 910 South Michigan Avenue, Chicago 80, Illinois.

STANDARD OIL COMPANY (INDIANA) STANDARD

How to make "Karbate" pipe connections



1. A "Karbate" flexible coupling ready for assembly. Note rubber gasket covering serrations on right hand pipe, ¼" from end. Gasket lying on table will be similarly applied over serrations on left hand pipe.

2. Flexible coupling being tightened in place.

KEEP "KARBATE" PIPE ALWAYS IN STOCK!

- Resists the action of acids, alkalies and other chemicals
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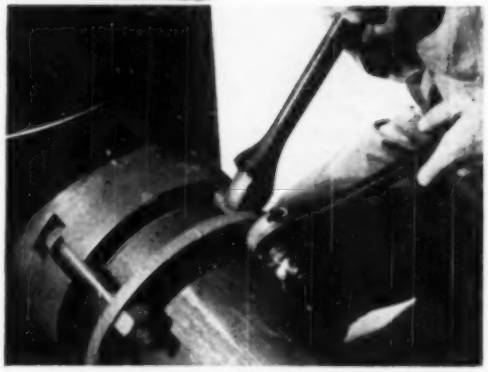

3. "Karbate" pipe being joined to gas inlet of a "Karbate" absorption tower by means of strong "Type V" flanged connection. Note flat place on bolt in foreground. This provides purchase for the second wrench to assure tightness in joint.

The term "Karbate" is a registered trade-mark of

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The Corrosion Forum

EDMOND C. FETTER, *Assistant Editor*

Fatty Acids versus Construction Materials

Part II of a symposium in which a representative group of construction materials are evaluated for services involving fatty acids.

Rubber Lining

O. S. TRUE, U. S. Rubber Co., New York, N. Y.

The entire series of commonly used fatty acids can be successfully handled in rubber lined equipment. The wide range of synthetic rubbers that are available together with natural rubber allows the tank lining compounder to design special linings to meet particular service conditions. Although rubber linings are resistant to fatty acids, as detailed below, fatty acid service is not ordinarily severe enough to call for this group of materials. Consequently they are not much used. There is an exception though: Sometimes fatty acids are encountered in low percentages, say 2-10 percent, in much more corrosive chemicals. That is what happens, for example, in the manufacture of glutamates. In such cases, if rubber is the answer to the corrosive chemical, one needn't fear the added presence of the fatty acid.

Hard natural rubber and butyl rubber compositions are satisfactory for the lower members of the fatty acid series, such as propionic acid. These linings are unaffected by the concentrated acids at temperatures up to about 160 deg. F. Since butyl rubber compounds are soft, they are the ideal choice where flexible linings are required, as for example in equipment that is alternately exposed to high and low temperatures.

The higher molecular weight fatty acids, such as lauric and stearic, should be handled in equipment lined with soft perbunan or hycar. These linings are resistant to the concentrated acids at temperatures as high as 180 deg. F. They have high tensile strength, excellent tear and abrasion resistance, and can be firmly adhered to most metals. Soft perbunan and hycar linings may be successfully applied to all types of equipment either in the rubber shop or in the field.

Soft natural rubber and neoprene linings should not be used with fatty acids.

The proper choice of these various lining materials makes it possible to protect storage tanks, reaction vessels, valves, pumps, pipe and fittings, from corrosion by fatty acids or combinations of fatty acids with other chemicals, such as animal, vegetable, and mineral oils.

Porcelain

JOHN S. CHOWNING, Lapp Insulator Co., LeRoy, N. Y.

As a general rule the commercial processing of fatty acids does not present a serious corrosion problem. Therefore, many of the common metals and ferrous and nonferrous alloys can be used satisfactorily as a material of construction for a great variety of chemical process equipment. This results in limiting the general use of chemical porcelain in the processing of fatty acids. Furthermore, economic factors and the manufacturing limitations on the shapes and sizes of equipment which can be fabricated from porcelain generally rule out its use for processing fatty acids.

However, where the processing of fatty acids requires chemical purity of product, freedom from metallic contamination; or where fatty acids are being processed in conjunction with more corrosive chemicals, chemical porcelain should be considered as a material of construction.

Chlorimet

WALTER A. LUCE, The Duriron Co., Dayton, Ohio

The Chlorimet alloys are very resistant to fatty acids at elevated temperatures. For instance, Chlorimet-3 is practically unaffected at temperatures approaching 600 deg. F. However, it is usually not necessary to resort to these high alloys when handling 100 percent fatty acids. When high purity is to be safeguarded, pumps and valves of the high alloy stainless steels are satisfactorily applied. The conventional stainless steels, 18-8-S and 18-8-S-Mo, aluminum, Monel and others are also extensively used in process equipment, pipelines, etc. Pumps and valves are also constructed from the 18-8-S-Mo alloy if a higher erosion-corrosion rate can be tolerated.

Chlorimet-3 is being used in services where the stainless steels, Monel, aluminum and others are not satisfactory. For instance, the wet end parts of a Duriron pump were converted to Chlorimet-3 for handling sulphuric acid acidified fatty acids at 150-180 deg. F. Although the Duriron was excellent from the corrosion standpoint, an alloy with better mechanical properties was desired to withstand steam cleaning of the transfer lines. Excellent results are being received due to the simple expedient of changing the wet end parts. Tests conducted on the other previously mentioned alloys indicated that Duriron or the Chlorimet type alloys should be applied if low corrosion and high purity are to be assured.

Chlorimet-3 is a nickel base, high alloy material with a nominal chemical composition of 60 percent Ni, 18 Cr, 18 Mo, 2 Fe and 0.07 C max. Chlorimet-2 is also a nickel base, high alloy with a nominal chemical composition of 63 percent Ni, 32 Mo, 3 Fe max. and 0.10 C. Tests indicate that the latter alloy shows a slightly higher corrosion rate than the Chlorimet-3 for fatty acids above 212 deg. F. Both these alloys are available in the cast form only and are machinable. At present, production is limited to pumps and valves.

Iron and Steel

A. W. SPITZ, American Cyanamid Co., New York

Iron and steel are not generally used in fatty acid service. Where product contamination is not objectionable, some fatty acids may be handled in steel providing the temperature does not exceed approximately 85 deg. F. Steel drums with a protective lining, however, are widely used for shipping commercial fatty acids.

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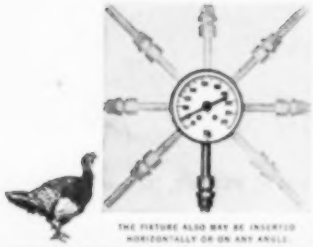

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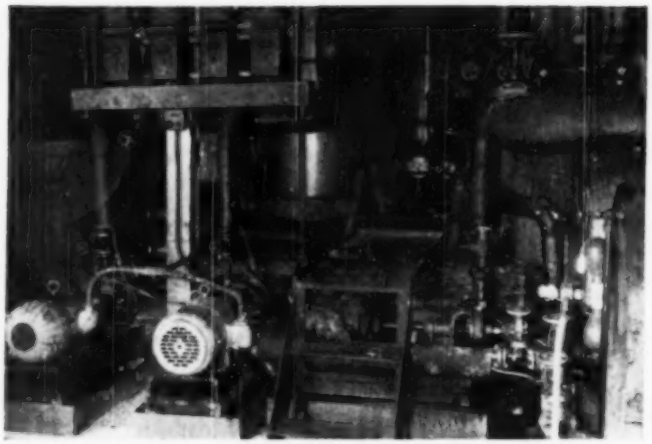
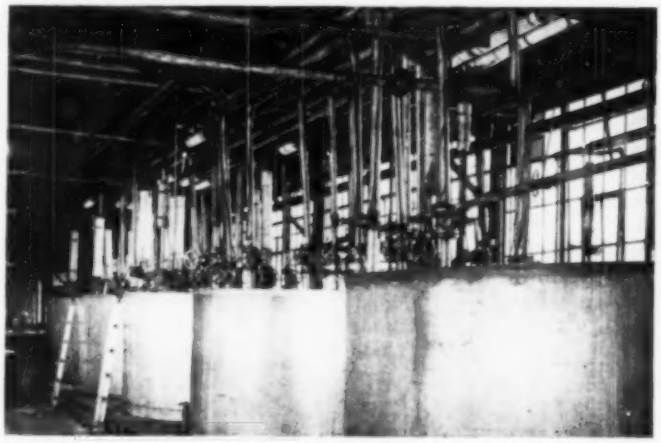


WORTHITE PUMPS discharge fatty acid still. Two at left handle purified fatty acids. Two on right handle pitch, or bottoms; pitch is at 400-500 deg. F.



WORTHITE VALVES, about 50 of them are shown, control flow of fatty acids to and from run-off and blending tanks. Pipes and tanks are stainless steel.

Worthite

W. E. PRATT, Worthington Pump And Machinery Corp., Harrison, N. J.

The principal application of Worthite for handling fatty acids is in the form of centrifugal pumps and gate valves. Hundreds of pumps and over a thousand valves are used for handling pure and crude fatty acids and mixtures, many containing such contaminants as sulphuric acid, Twitchell reagents, glycerine, salt, spent lye, and various catalysts.

Some of the austenitic stainless steels are, in general, satisfactorily resistant to the fatty acids but where high velocity is encountered, as in centrifugal pumps, especially with sulphuric acid present, the higher alloyed, "super-stainless" Worthite analysis is considered more economical. In the case of Worthite valves versus 18-8 moly valves the cost of Worthite averages 10 to 15 percent higher. However, in the case of Worthite centrifugal pumps, due to standardization on the one grade of Ni-Cr-Mo alloy, and thereby achieving large volume production, Worthite pumps are actually lower in price than our ordinary stainless steel pumps of equal construction.

In 1940 a series of tests was made by a large soap company on various metals in hot fatty acids. This company's report contains the following

(Continued)

MORE EVIDENCE ON HOW DURCO EQUIPMENT MINIMIZES THE COST OF HANDLING CORROSIVES

Here are more examples of how the use of Durco equipment has avoided costly replacements and shutdowns.

These photographs show what Durco means by "corrosion-resistance . . . years, even decades of unfailing corrosive-handling service. This corrosion-resistance is not provided by any coating or lining; it is inherent in the alloy of which the equipment is made. It is uniform throughout the entire wall thickness.

Durco has specialized in developing and producing corrosion-resistant alloys and equipment for services like these for the past 37 years.

This Duriron pump and strainer are continuing to handle this severe abrasive and corrosive solution
20 YEARS
HANDLING FERRIC FERRO-CYANIDE
This Duriron tap lubricated plug valve is still giving trouble free service.
13 YEARS
HANDLING 20 Be. HCl
This Durichlor pump is on the job today.
13 YEARS
HANDLING 20 Be. HCl

DURCO ALLOYS INCLUDE:

DURIRON and DURICHLOR—high silicon irons
DURIMET—a high Ni-Cr-Mo-Cu, low carbon stainless steel
CHLORIMET NO. 2—Nickel base, high molybdenum alloy
CHLORIMET NO. 3—Nickel base, high Mo, high Cr alloy
Also **DURCO D 10, MONEL, INCONEL, PURE NICKEL, NI-RESIST, STEEL,** and **CAST IRON**

DURCO EQUIPMENT INCLUDES:

CENTRIFUGAL PUMPS
VALVES
PIPE AND FITTINGS
HEAT EXCHANGERS
STEAM JETS
TANK OUTLETS
EJECTORS
KETTLES
AND OTHER TYPES OF PROCESS EQUIPMENT

Send for these two bulletins. They will give you an overall look at what Durco has to offer you.

DURCO
CORROSION RESISTING ALLOYS

THE DURIRON CO., INC.
DAYTON 1, OHIO
Branch Offices in Principal Cities

Durco Adv. 88-GM

THE DURIRON CO., INC., DAYTON 1, OHIO

Gentlemen:

Please send me, without obligation, your bulletin 100—"Guide To Selection of Durco Corrosion-Resisting Alloys" and "General Catalog K".

Name_____ **Title**_____

Company_____

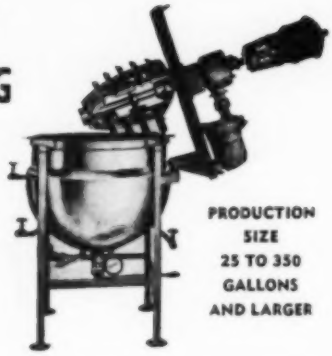
Address_____

City_____ **State**_____

A NEW TOOL FOR BETTER MIXING

THE **AGI MIXER**

TWO MIXERS IN ONE



PRODUCTION SIZE 25 TO 350 GALLONS AND LARGER

Combines Paddle Mixer and Homogenizer

The new AGI-MIXER (incorporating our HOMO-MIXER) gives a FINER mix than any other apparatus, frequently in 1/10th the time. Material is agitated slowly by the paddles of AGI-MIXER, being worked downward to the HOMO-MIXER, which mixes and shears at high speed and pressure. This produces particles of extremely fine size, which are ejected upward again to the AGItator paddles. Thick heavy viscous mixtures can be mixed and homogenized at the same time. We furnish complete outfit, including motors and kettle. Sizes from laboratory to production plant.

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(CORK CUSHIONED)

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13 GALS.

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5 & 13 gallon sizes

to comply with ICC—1A

Available in 6½ gallon size to comply with specification ICC-1D

HERCULES *Aero*

(RUBBER CUSHIONED)

CARBOY BOXES

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NATIONAL BOX & LUMBER COMPANY

HOME OF HERCULES CARBOY BOXES • NEWARK 5, N. J.

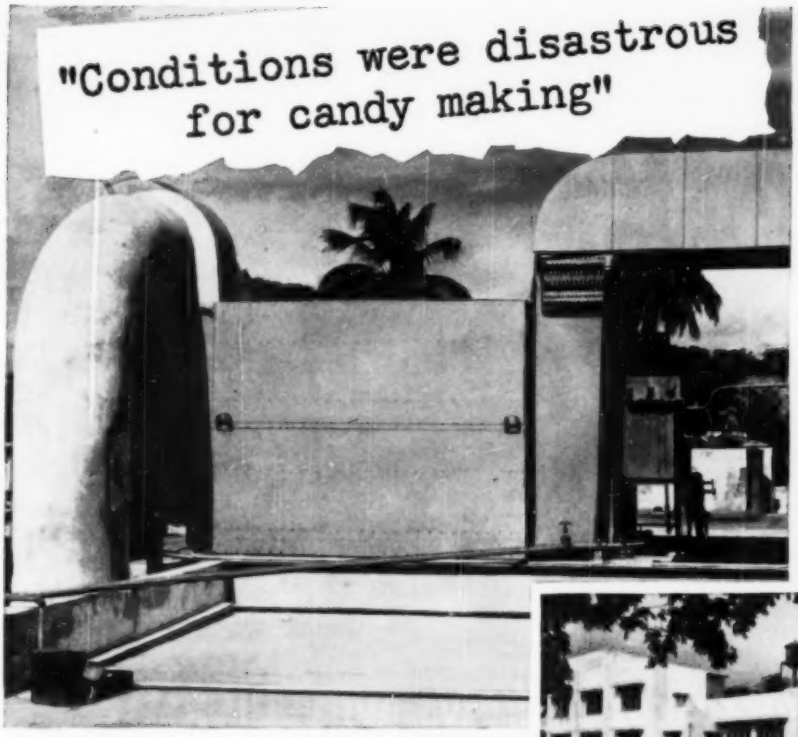
data on various metals exposed to liquid fatty acids at a temperature of 550 deg. F. for a period of 60 days in a commercial fatty acid still with violent circulation.

	Mils Per Year
Cast Worthite	0.6
Pure Silver	0.8
Coin Silver	1.6
Silver Solder, 1,400°F. M.P.	3.7
Silver Solder, 1,300°F. M.P.	16.3
Silver Solder, Copper Free	2.5
Inconel	2.5
Type 316 Stainless	4.1
Type 317 Stainless	2.8
Type 347 Stainless	10.0
18-8 Stainless	15.2

The above tests led to the general use of Worthite pumps and valves, and now with the advent of continuous soap processes the organization is greatly expanding the application of Worthite. While the continuous fat splitting and soap processes differ, they all require numerous low to medium pressure centrifugal pumps for circulating, transferring and filtering, for which standardized Worthite pumps are available. Over 200 Worthite pumps were purchased in 1948 for these processes.

Other processes involving fatty acids, where Worthite pumps and valves are widely used, are tall oil refining, sulphonated oils and esters, solvent extraction, glycerine refining, hydrogenation, catalyst recovery, dehydration. The acidified or "spent lye" common to the low pressure fat splitting process is considered to be one of the more corrosive solutions to be handled in such plants. A recent test of a Worthite specimen in the "spent lye" tank showed no measurable corrosion. Many plants use Worthite pumps and valves for transferring and filtering operations in the glycerine recovery process.

Woburn Chemical Corp. uses both the Twitchell process and the batch autoclave high pressure process for splitting fats and oils of all kinds. Their processes, therefore, involve practically the whole gamut of corrosive conditions encountered in the production and treatment of fatty acids. About 25 Worthite centrifugal pumps and between 200 and 300 Worthite valves are used throughout the plant, the first application being made in 1936. Some excellent photographs of the various types of equipment in the Woburn plant at Kearny, N. J., were published in *Chemical Engineering* for August 1947. The illustration of the blending tanks on page 109 of that issue shows a Worthite pump and a number of Worthite valves. The accompanying photographs show in more detail a few of the many applications of Worthite in this plant. —End



This Lectrodryer, mounted on the roof of Ponce Candy Industries' plant at Ponce, Puerto Rico, maintains a relative humidity of 55% in the department where "Fiesta" candies are wrapped.

Lectrodryer solved that problem and helped step up production 10%

Mr. Rafel Pou, Plant Manager, reports: "We ran into lots of trouble before we had the Lectrodryer installed. Now we are maintaining a temperature of 75° and a relative humidity of 55% with one CHT Lectrodryer and a 30 HP Chrysler Airtemp unit. During the winter, when the temperature drops, we save a lot of electric current by using the Lectrodryer alone."

"... production has stepped up at least 10%, because our automatic wrapping machines now operate at top efficiency."

You don't have to work in the tropics to have trouble with high humidities. Lectrodryers are providing "winter weather the year around" in such cities as Spokane, Minneapolis, Chicago, Cleveland, Buffalo, Philadelphia, and on around the world. Production has been standardized, quality of products improved, by making plants independent of outside weather conditions.

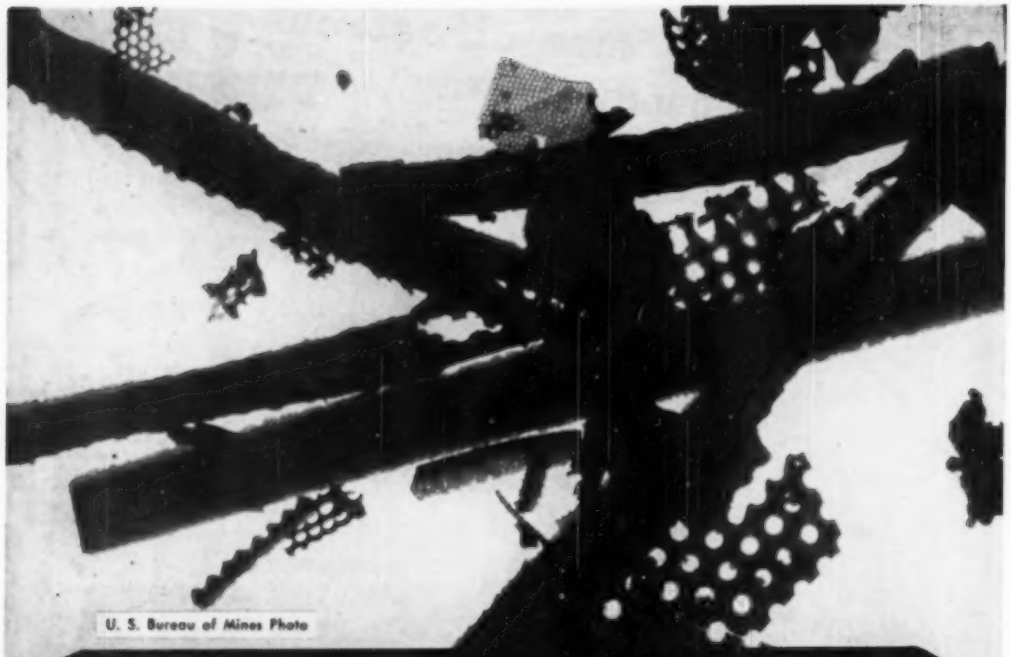
Whether the moisture that's giving you trouble is in the air, in a gas or organic liquid, there's a Lectrodryer to remove it. Tell your DRYing problem to Pittsburgh Lectrodryer Corp., 303 32nd Street, Pittsburgh 30, Penna.

In England: Birlec, Limited, Tyburn Road, Erdington, Birmingham.
In Australia: Birlec, Limited, 51 Parramatta Road, Glebe, Sidney.

LECTRODRYERS DRY WITH ACTIVATED ALUMINAS

LECTRODRYER

REGISTERED TRADEMARK U.S. PAT. OFF.



U. S. Bureau of Mines Photo

The microscope shows why DICALITE® filteraids give brilliantly clear liquids

The photo reproduced above shows particles of Dicalite Speedflow magnified 6,000 times by the electron microscope. It illustrates more graphically than many words the reason Dicalite filteraids give brilliant clarity at high flowrates. The "needle-like", elongated, or otherwise irregularly-shaped particles assume a "straw-pile" arrangement in the filter cake. Millions of microscopically fine interstices are formed which trap the smallest solids, yet allow liquor flow at high rates. Besides Dicalite Speedflow there are other grades affording a wide range of performance so that you can regulate the operation of your filter station to meet production demands, or maintain desired clarity and output with liquors of varying filterability. Complete data gladly sent on request.

DICALITE DIVISION, GREAT LAKES CARBON CORPORATION

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Names in the News

MAN OF THE MONTH

R. L. Murray

On May 17, R. L. Murray, executive vice president of the Hooker Electrochemical Co., Niagara Falls, was awarded the 1949 Jacob F. Schoellkopf Medal of the Western New York Section of the American Chemical Society.

Mr. Murray, who has been with the Hooker company since 1916, was the nineteenth recipient of the medal, which is conferred annually upon a Western New York chemist or chemical engineer for outstanding achievement. He was cited "for his engineering ability and for his unusually able direction of chemical research and development in the chlorine and alkali industry."

As vice president in charge of research and development from 1941 until he became executive vice president last January, Mr. Murray supervised the development of many important chemicals by Hooker during World War II. Among them were dodecyl mercaptan, a compound used in making synthetic rubber; aluminum chloride for synthetic rubber and 100-octane gasoline; hexachloroethane for smoke shells and smoke pots; hexachlorbenzene for Signal Corps colored flares; lauryl pyridinium chloride for disinfectants; new additives for motor oils and gear lubricants; compounds to protect textiles against fire, water, and mildew; and improved plasticizers to keep clothing and tarpaulins from becoming stiff in Arctic regions.

Mr. Murray also collaborated in the development of the important new insecticide benzene hexachloride, also known as BHC. He was sent to Germany toward the end of the war as a special investigator for the Chemical Warfare Service to survey German chemical plants manufacturing military chemicals, and prepared numerous reports on various phases of German chemical production at that time.

Born in San Francisco on Nov. 3, 1892, Robert Lindley Murray received the B.S. degree in chemistry in 1913 and a chemical engineering degree in 1914 from Stanford University. After a brief period as a draftsman at the Western Sugar Refinery in San Francisco, he became works chemist for the Pacific Coast Borax Co. in Alameda, Calif., and later was transferred to the East as assistant to the superintendent of the company's Bayonne, N. J. plant.

Joining the Hooker company as research chemical engineer, he assisted in operating an explosives plant for the government in 1917-18, and became plant superintendent in 1920. He was promoted to chief engineer in 1932, and made director of development and a member of the board of directors in 1937. In addition to his present office in the Hooker company, he is vice president and a director of the Hooker Detrox Co., Inc., which has a plant in Tacoma, Wash.

Mr. Murray was national singles tennis champion in 1917 and 1918, and also at one time held the Pacific Coast record for the half-mile run.

A former representative of the Western New York Section on the American Cemical Society's national Council, Mr. Murray has been a director of the American Institute of Chemical Engineers. He is a member of the American Association for the Advancement of Science, the Electrochemical Society, the American Arbitration Association, the Chemical Corps Association, Phi Beta Kappa, Sigma Xi, Phi Lambda Upsilon, and Kappa Alpha.

Clayton W. Reynolds, who recently completed 30 years service with the Sherwin Williams Co. of Canada Ltd., has joined the firm of Casgrain & Charbonneau Ltd., Montreal, as technical adviser of the scientific instruments division.

Lloyd V. Sherwood has been named assistant coordinator of the agricultural chemicals group of Monsanto Chemical Co.'s organic development department.

W. L. Rippeteau has been appointed manager of development for Wyandotte Chemical Corp.

W. J. Osbora has been appointed district manager at San Francisco for Hagen Corp., Pittsburgh. He succeeds **Clyde F. Williamson** who has resigned.

Sidney D. Kirkpatrick was elected a vice president of the McGraw-Hill Book Co. at its board meeting April 25. He has been the consulting editor for chemical engineering texts and reference books since 1928, a director since 1936. Dr. Kirkpatrick will continue as editor of *Chemical Engineering*.

S. D. Kirkpatrick

L. L. Malm

L. Louis Malm has been named chief engineer of Industrial Rayon Corp. Malm joined the rayon company's headquarters engineering staff in 1944, and was named plants and process engineer in 1945.

Nicholas M. Walker has been appointed to the packaging and labeling division of Pennsylvania Salt Manufacturing Co. to assist in matters relating to labeling and registration of Pennsalt products.

Frederick S. Bartlett has been appointed factory manager of the Bristol, R. I., plant of United States Rubber Co.

Howard A. Sommers has been appointed manager of carbon dioxide plant operations for Pure Carbonic, Inc., with headquarters in New York.

Warren L. McCabe has been made a vice president of Flintkote Co.

Robert E. Wilfong, research chemist in the acetate research section of the rayon technical division of E. I. du Pont de Nemours & Co. at Waynesboro, Va., **Linton G. Ray, Jr.,** and **John P. Wilkins,** research group leaders in the rayon pioneering research section at Buffalo, N. Y., have been promoted to research

(*Continued*)

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FILTER FABRICS
OVER 40 DIFFERENT WEAVES
FILTER TWILLS, CHAIN CLOTHS
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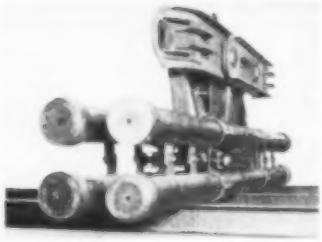

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Established 1909
NEW BRUNSWICK, N. J.
★ ENGINEERS—
★ FABRICATORS—
★ ERECTORS—
Inquiries Invited

NAMES IN THE NEWS, *cont. . .*

supervisors. **Chiles E. Sparks,** a research supervisor in the rayon pioneering research section at Buffalo, has been transferred to Wilmington as coordinator of dye work on fibers and will be liaison with the organic chemicals department group working in the same field.

Carl F. Prutton has been appointed vice president-director of operations of all the Mathieson Chemical Corp.'s plants and **Arthur T. Bennett,** vice president, has been placed in charge of the eight plants acquired from Southern Acid and Sulphur Co. **R. B. Worthy** and **J. F. Newell** have been named vice presidents.

C. F. Prutton

J. J. Morrisroe

John J. Morrisroe has been appointed research director of Purex Corp., Ltd., South Gate, Calif. He was formerly manager of technical service for Oronite Chemical Co., San Francisco. Morrisroe, who has had considerable experience in synthetic resin and paint research, is a chemical engineering graduate of Columbia University.

Frank J. Curtis, vice president in charge of coordinating sales, and **Carroll A. Hochwalt,** vice president and coordinator of the company's research, development and patent activities, have been elected to the board of directors of Monsanto Chemical Co.

George M. Hartley has been named materials engineer for the chemicals division of the General Electric Co.'s chemical department. He will be responsible for purchasing, controlling inventories, and scheduling the flow of all raw materials through the four chemicals division plants at Pittsfield; Anaheim, Calif.; and Schenectady and Waterford, N. Y.

Bruce H. Sage, professor of chemical engineering in the California Institute of Technology, is the first recipient of the new $1,000 Precision Scientific Co. Award in petroleum chemistry. The award will be presented next September at the American Chemical Society's fall meeting in Atlantic City.

A. P. Black, president-elect of the American Water Works Association, has been named head of the department of chemistry at the University of Florida. He has been a member of the faculty since 1919. He succeeds the late **Townes R. Leigh.**

Russell W. Mumford has been appointed vice president in charge of technical operations for American Potash & Chemical Corp. With his new appointment, he retains the position of consulting engineer. As vice president in charge of technical operations, Mumford succeeds **Samuel Cottrell** who resigned recently.

Gordon Kiddoo, New York, is now specializing as a consultant on synthesis gas production; synthesis of fuels and chemicals from natural gas, oil, and coal; oxygen production; fluidization of solids; gasification and utilization of coal; and pilot plant design and operation.

Alfred L. Ferguson, professor of chemistry at the University of Michigan, has been elected president of the Electrochemical Society for the 1949-1950 term. Dr. Ferguson has been a member of the society since 1918 and has long been active in society affairs.

A. L. Ferguson

E. A. Haagensen

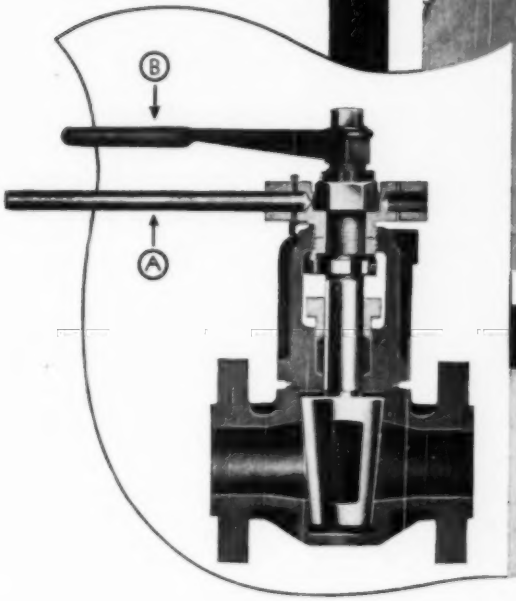
Howard A. Sommers has been appointed manager of carbon dioxide plant operations for Pure Carbonic, Inc., with headquarters in New York.

Paul R. Austin, an assistant director of the chemical department laboratory at Du Pont's experimental station in Wilmington, has been appointed director of the electrochemicals department's technical division. **Harold J. Barrett,** chemical research manager at the Niagara Falls, N. Y., plant, was named manager of field research with headquarters in Wilmington. **Campbell Robertson,** manager of chemical research at the Perth Amboy, N. J., plant has succ-

(Continued)

"Instant, Stick-Proof Operation *at all Times, Under all Conditions*"

with HOMESTEAD Lever-Seald Valves



NOTE THESE OUTSTANDING FEATURES

1. Instant Stick-proof operation.
2. Quarter-turn fully opens or closes.
3. Positive seal without lubrication.
4. Seating surfaces always protected in both open and closed positions. Corrosion practically eliminated.
5. Unobstructed straight-line fluid flow.
6. All operating parts protected from damaging effects of service conditions and weather.

A powerful lever-and-screw device—built into each valve—prevents sticking and assures positive action at all times and under all conditions. Corrosive or viscous fluids, temperatures as low as 40° below Zero or as high as 1120° F., pressure or other adverse conditions that ordinarily cause valve failures, cannot affect the operation of Homestead Lever-Seald Valves.

Homestead Lever-Seald Valves operate faster too, 16 to 28 times faster than screw-stem-type valves. Seating pressure is first relieved with the lower lever "A" just enough to overcome friction. Then a quarter-turn of the upper lever "B" fully opens or closes the valve. Full seating pressure is again applied with the lower lever to make a positive, leakless seal.

Homestead Lever-Seald Valves can be furnished in combinations of metals and alloys to suit your requirements in sizes 1¼" to 10", for pressure from vacuum to 1500 pounds.

Write today for full information and copy of Section 3, Valve Reference Book No. 39.

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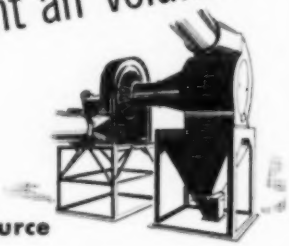
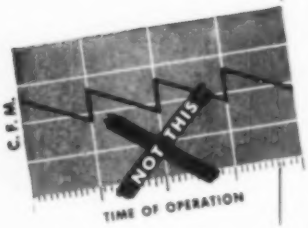
Continuous dust control demands constant air volume

Roto-Clone's uniform air delivery assures constant effective control at dust source





THE two charts at left tell an important story. The one above shows how rapidly air volume declines as ordinary type collectors become clogged with dust. Result—constantly varying exhaust volume with parallel variations in effectiveness of control at point of dust generation.

Now examine the chart below. This is a Roto-Clone* at work. Constant air volume is exhausted hour after hour, day in and day out. Continuous high efficiency dust collection is assured without a minute's time out for unit maintenance.

The Roto-Clone method of dust control applies centrifugal and dynamic forces in combination to remove the dust particles from the air stream. There are no collecting elements to clog or clean. Dust is discharged automatically for easy removal without interference to operation.

If you want to put dust control on a continuous high efficiency basis, you will want to put Roto-Clone with its small space requirements on the job. There's a type and size for every service. For complete information, contact your local AAF representative or write direct for copy of Bulletin No. 270-A.

*Roto-Clone is the trade-mark (Reg. U. S. Pat. Off.) of the American Air Filter Company, Inc., for various dust collectors of the dynamic precipitator and hydro-static precipitator types.

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AAF

ROTO-CLONE®
DUST CONTROL EQUIPMENT

Names in the News, cont . . .

ceeded Dr. Barrett at the Niagara Falls plant. **Earle A. Harding,** who has been director of the technical division, and **Paul J. Carlisle,** who has been manager of field research, will retire from active service about the end of this year. Until that time they will serve as special assistants to their successors.

William M. Lofton, Jr., has been named director of the division of research and development, Sloss-Sheffield Steel & Iron Co., Birmingham, Ala.

P. W. Leppla has been appointed associate director of research and **Harold Reintjes** is associate director of development for the research and development division laboratory of Great Lakes Carbon Corp. at Morton Grove, Ill.

Richard T. Arnold of the University of Minnesota has been named winner of the $1,000 American Chemical Society Award in Pure Chemistry, financed by Alpha Chi Sigma, national chemical fraternity. Presentation will take place next fall in Atlantic City.

Arthur B. Lamb, for the past 30 years editor of the "Journal of the American Chemical Society," has been awarded the Priestley Medal of the ACS. Presentation will be made next fall in Atlantic City.

Robert L. Moore, formerly vice president in charge of research and development, Robbins Tire and Rubber Co., Tuscumbia, Ala., has recently accepted the position of director of research and product development, United States Asbestos Division, Raybestos-Manhattan, Inc., at Manheim, Pa.

Roy G. Hemminghaus, formerly a manufacturing superintendent at Monsanto Chemical Co.'s John F. Queeny plant in St. Louis has been appointed to the newly created post of general production superintendent.

Joseph H. Bianco has joined the ester division of the Glyco Products Co., at Natrium, W. Va. He is a graduate in chemical engineering of the Drexel Institute of Technology and was formerly connected with Du Pont's Grasselli Chemical Division.

John W. Copenhaver has joined the M. W. Kellogg Co. as head of one of its research groups in the Jer-

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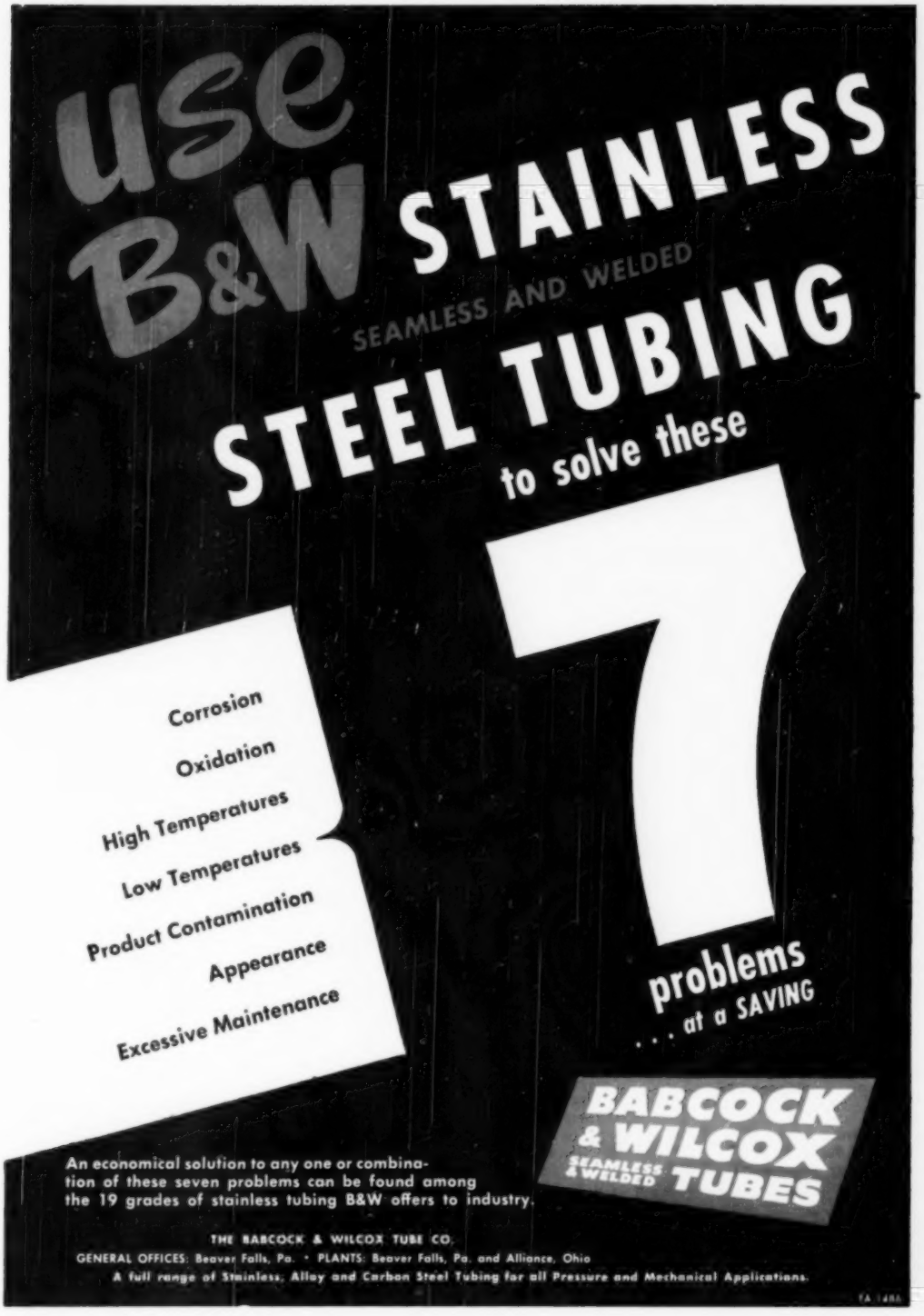
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STEEL TUBING
to solve these
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Excessive Maintenance
An economical solution to any one or combination of these seven problems can be found among the 19 grades of stainless tubing B&W offers to industry.
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NAMES IN THE NEWS, cont . . .

sey City, N. J., petroleum and chemical research laboratory. He was formerly with General Aniline and Film Corp. at Easton, Pa.

Osborn R. Quayle, professor of chemistry at Emory University, has been awarded the Herty Medal for outstanding contribution to chemistry in the Southeast. Presentation of the medal was made May 7.

David S. Weddell, who has been in the general development department of Monsanto Chemical Co. in St. Louis for the past two years, has been made director of development for Monsanto's western division in Seattle.

R. B. Mears

F. L. La Que

R. B. Mears, manager of the research laboratory of Carnegie-Illinois Steel Corp., Pittsburgh, Pa., received the 1949 Willis Rodney Whitney Award of the National Association of Corrosion Engineers April 13. The 1949 Frank Newman Speller Award went to **F. L. La Que**, in charge of the corrosion engineering section, International Nickel Co., Inc., New York. Mears is the incoming and La Que, past president of the association.

D. S. Snow, D. D. Hamilton, and **J. M. Kamps** have been appointed to new positions in the sales organization of the tar products division of the Koppers Co. Snow has been named assistant manager of the divisional sales department. Hamilton has been promoted to manager of Pittsburgh district sales. Kamps has been advanced to divisional manager of building materials sales.

John R. Ferree has been appointed superintendent of production at the Los Angeles, Calif., plant of the Sherwin-Williams Co.

Robert W. Schramm has been added to the market research staff of Spencer Chemical Co., Kansas City, Mo.

John M. Corliss, recent graduate of Loyola College, has joined the

(Continued)

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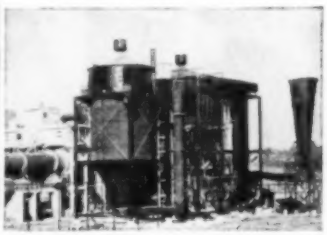

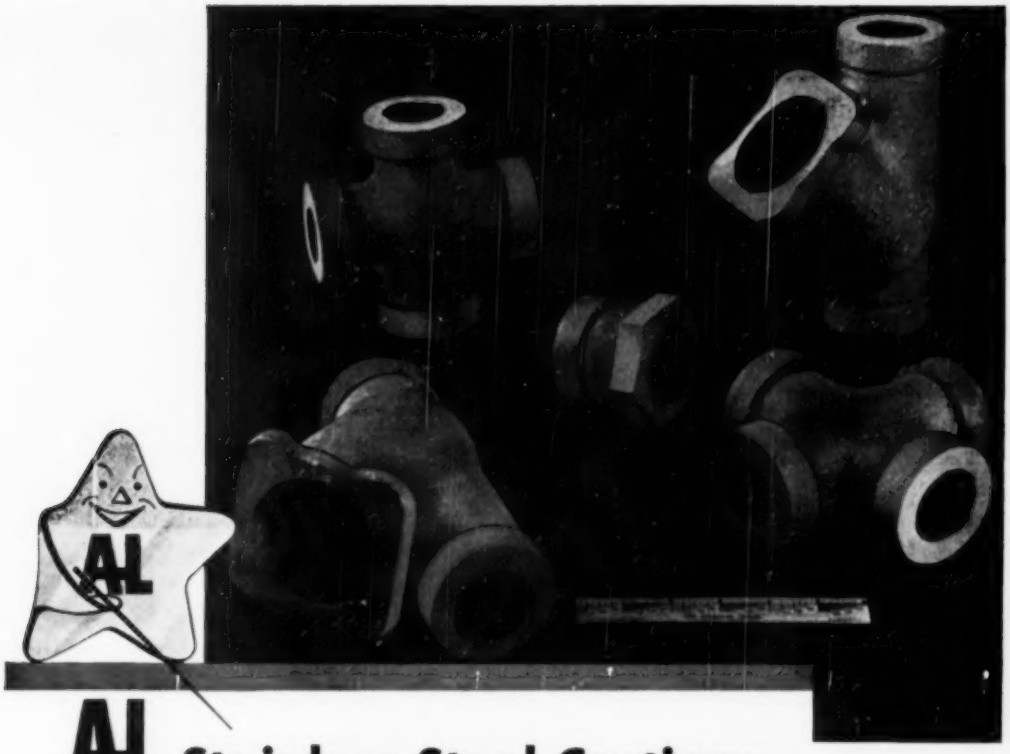

AL Stainless Steel Castings meet any need for Cleanliness

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Available *now*—informative booklets on Allegheny Metal in the Chemical, Petroleum Refining, Brewing, Meat Packing, and Dairy Industries—others in preparation. Write for this valuable data on the field in which you are interested.

ADDRESS DEPT. C-75

Note the clean, sound, fine-grained appearance of the Allegheny Metal sanitary fittings shown above, in the "as-cast" condition. They're typical of the wide variety of stainless steel castings we produce for the chemical processing, food, dairy, beverage, oil, paper and textile industries, etc.—wherever the purity and quality of products must be maintained, and where ease of sanitation and assurance of long, trouble-free service are prime considerations.

Allegheny Metal castings are produced by methods specially developed to protect uniform quality and guard against defects. You'll find them superior both from the standpoint of machinability and soundness. ● Let us quote on your stainless casting requirements—any shape and any size, from a few ounces to 5000 pounds.

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In the Roberts Fluid Drive Centrifugal and only in the Roberts machine are the following features to be had:

★

Standard motor with current peak less than 40% of direct-connected (special) motor drives.

★

Uniform torque, with adjustable application.

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Simple adjustment for accurate speed control.

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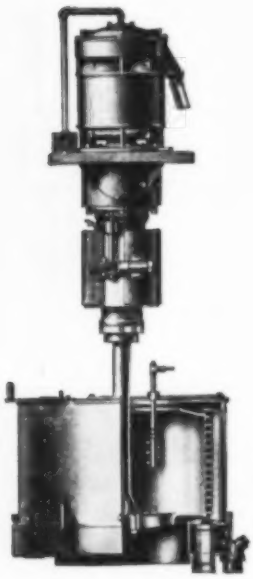

The inherent design of our Fluid Drive machine allows special characteristics to be incorporated with ease, thus suiting it exactly to special applications. Let us show you how it can be made to work for your benefit. Send us your inquiry now . . . it imposes no obligation.

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NAMES IN THE NEWS, cont . . .

Analytical Branch, Chemical Division, Technical Command, Army Chemical Center, Md., as an analytical chemist.

Richard E. Hudson, Jr., has been appointed head of the textile section of the applied chemistry division of Southern Research Institute, Birmingham, Ala.

Elmer C. Larsen has been named chief engineer for the tungsten and chemical division of Sylvania Electric Products, Towanda, Pa. Dr. Larsen was formerly assistant director of research for the J. T. Baker Chemical Co.

George L. Parkhurst has been elected a vice president of Standard Oil Co. of California. He has been president of Standard's Oronite Chemical Co., San Francisco, since 1947.

Joseph Dahle, formerly research director of Symco Chemical Corp. and Aspinook Corp., has been appointed director of research for the Atlas Mineral Products Co.

Adolph Harvitt, general manager of the magnetic pigment division of the Columbian Carbon Co. has been elected a director of the parent company and is currently serving in New York as assistant to President C. E. Kayser.

H. F. Leilich, formerly mechanical engineer and power plant project manager for the Rust Engineering Co., has joined the staff of the Peter F. Loftus Corp., engineering consultants, of Pittsburgh.

H. Neville Potter has been named executive vice president and general manager of Dearborn Chemical Co. (Toronto) of Canada.

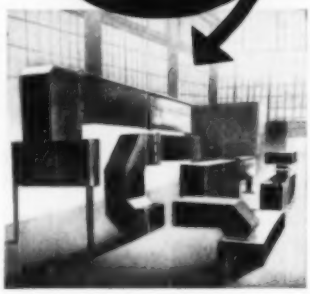
James H. Fry has resigned his position with the American Sugar Refining Co. to accept a position as research chemist with the Atlas Mineral Products Co.

Edward H. Snyder has been elected president of American Zinc Institute. Snyder, who is president of Combined Metals Reduction Co., Salt Lake City, succeeds **Howard I. Young** who has held the office since 1935.

Roy H. Kienle has been chosen to deliver the first Joseph J. Mattiello Memorial Lecture before the Federation of Paint and Varnish Pro-

(Continued)

Fume Duct Maintenance NO LONGER A PROBLEM HERE!



• One plant made this installation entirely from HAVEG—and then stopped worrying about damaging, corrosive fumes. HAVEG can give *you* the same freedom from corrosion problems, too. It is a different molded material that resists chemical action *through its entire mass.* Not just a lining or coating, it is not affected by surface gouges or abrasion. What's more, it is strong and lightweight. Resists shock. And it is remarkably easy to machine!

In tanks, blowers, agitators, valves, piping, pumps, towers—in a hundred and one applications—HAVEG can help you lengthen process equipment life, reduce maintenance costs. A trial order will convince you—send yours in today. Or, write for Bulletin F-5—it contains engineering and application information that will interest you.

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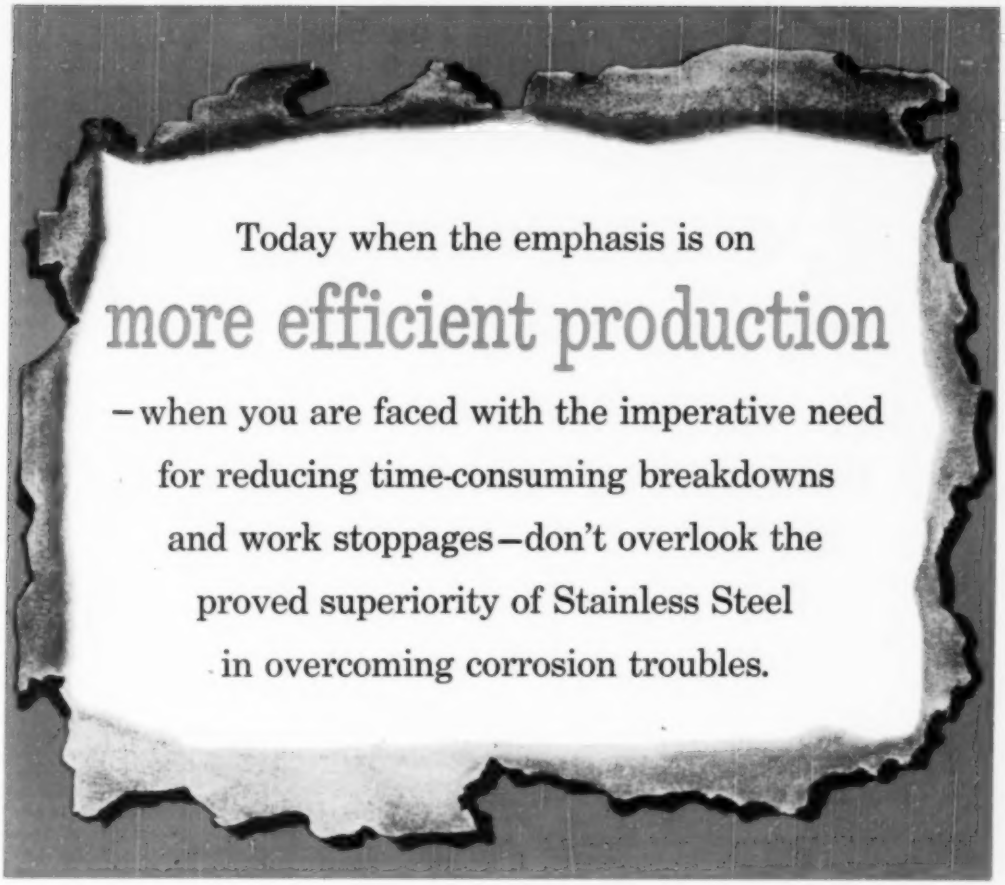
Today when the emphasis is on
more efficient production
–when you are faced with the imperative need
for reducing time-consuming breakdowns
and work stoppages–don't overlook the
proved superiority of Stainless Steel
in overcoming corrosion troubles.

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To help you apply these superior corrosion-resisting and heat-resisting steels most economically, our stainless steel specialists are at your service. The research facilities of the world's largest producer of fine steels stand behind them.

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SHEETS · STRIP · PLATES · BARS · BILLETS · PIPE · TUBES · WIRE · SPECIAL SECTIONS

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I* P* E PRECISION STOPS SHAFT WOBBLE!

Shaft wobble has been the main cause of leakage in old-style side-entering agitators.

When shaft wobble started, the inflexible packing opened and leakage followed. Pulling down harder on the gland merely caused the packing to give way, further aggravating the condition.

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- Line-bored, all-welded steel housing
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—Blending in extra-large tanks—mixing in conical-bottomed crystallizers—sweeping the bottom of settling solids—stirring organic and inorganic chemicals—used in low headroom conditions.

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duction Clubs' annual convention at Atlantic City in November. Dr. Kienle is director of application research, American Cyanamid Co., Calco Chemical Division. He is assistant research director of the American Cyanamid Co.

Eugene L. Woroch has joined the staff of the Bjorksten Research Laboratories as a section leader, and **James E. Henning** as a research chemist.

W. E. Hanford, director of petroleum and chemical research, has been elected a vice president of the M. W. Kellogg Co. Prior to joining the Kellogg organization in 1946, he was director of research of General Aniline & Film Corp.

W. E. Hanford

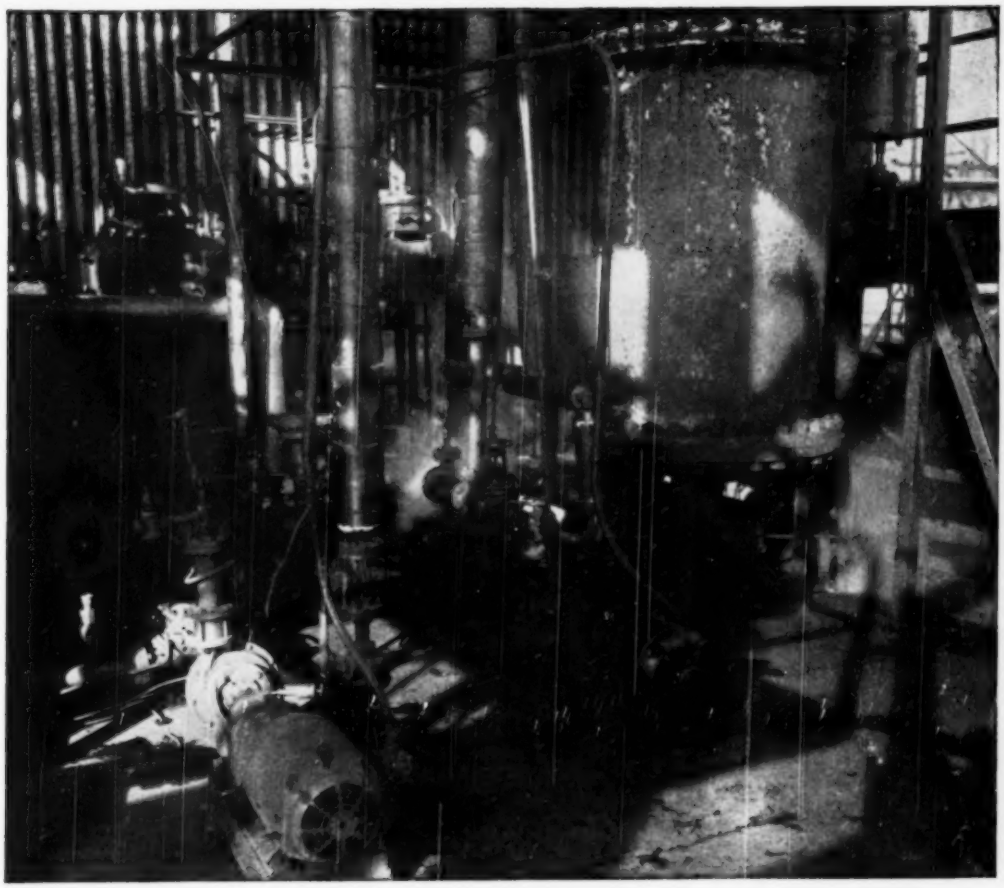
W. N. Williams

William N. Williams has been appointed assistant to the executive vice president, Westvaco Chemical Division of Food Machinery and Chemical Corp., New York. Previously head of the production department, Williams will now be concerned with general administration of all departments. He will continue as vice president of Westvaco. **Fred S. Rooney,** formerly assistant to Williams, has been made acting manager of production with **Raymond F. Moran,** previously central process control director, as his assistant.

John H. Vohr, who has been assistant general superintendent of the South Chicago plant of Carnegie-Illinois Steel Corp. for the last four years, has been promoted to the general superintendency of the company's Gary Steel works. Vohr succeeds **Stephen M. Jenks,** who has been promoted to Chicago district manager of operations of the company. **Edwin H. Gott** succeeds Mr. Vohr.

Warren L. Wollrab has been engaged as a junior development engineer by A. E. Staley Manufacturing Co., Decatur, Ill. Other recent appointments in its technical service and research division are **William R.**

(*Continued*)



. . . and they specify LABOUR

Creosote tar acid oil, heated to 550° F., is handled at a 60-foot head by the two LaBour pumps at the right in the above picture. The other two LaBour pumps are moving carbolic acid at 250° F.

LaBour pumps won these jobs because of the user's experience with other LaBour pumps; they provide maximum assurance against process interruptions due to untimely pump failure. Extreme simplicity of LaBour design eliminates trouble-breeding complications. Thorough-going care in building—checked step by step with elaborate tests including actual operation under specified head and capacity conditions before shipment—reduces the possibility of service difficulties to the vanishing point.

That's why those who realize what they're up against in handling difficult process problems take no chances. They know they need LaBours . . . and they specify LaBour.

LaBOUR CENTRIFUGAL PUMPS

THE LABOUR COMPANY, Inc. • ELKHART, INDIANA, U.S.A.

New GOULDS

Self-Priming Sump and Utility Pump

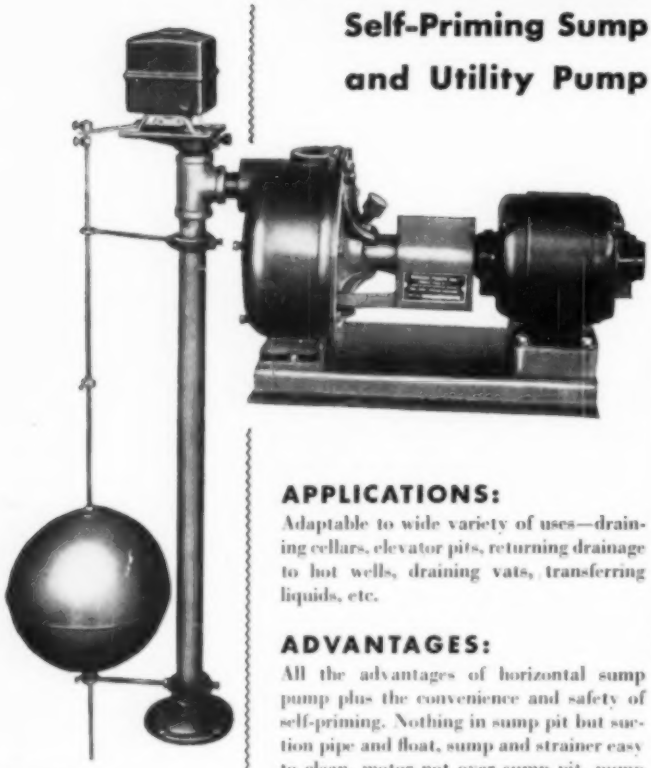


Fig. 3232

APPLICATIONS:

Adaptable to wide variety of uses—draining cellars, elevator pits, returning drainage to hot wells, draining vats, transferring liquids, etc.

ADVANTAGES:

All the advantages of horizontal sump pump plus the convenience and safety of self-priming. Nothing in sump pit but suction pipe and float, sump and strainer easy to clean, motor not over sump pit, pump and motor accessible always, built for continuous operation.

SIZES:

Normally supplied for 2 ft. and 5 ft. pit depths but can be used for pit depths up to 15 ft. by use of extra pipe and rod. Capacities up to 30 gals. per min. depending on head.

The utility pump (fig. 3230) is same as sump but without float switch and suction pipe.

Write for Bulletin 635-A-1 for complete details.

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The Right Pump For Your Job

PUMPS, INC.

Dept. CE, SENECA FALLS, N. Y.

Please send your FREE bulletin 635-A-1 to:

YOUR NAME_____

COMPANY_____

STREET_____

CITY_____ STATE_____

CONVENTION PAPERS, cont. . .

Eichenberger, research chemist; **Donald E. Paul,** junior research chemist; and **Richard C. Hansen,** chemist.

William S. Loose, former director of the laboratory development section of the magnesium laboratory, has been appointed magnesium division sales manager for the Dow Chemical Co.

John Z. Linsenmeyer has been appointed manager of mining, petroleum and chemical engineering for the Westinghouse Electric Corp.

Earle W. Mills, vice admiral USN (Ret.), has been elected executive vice president and director of Foster Wheeler Corp., and **David McCulloch,** formerly executive vice president has been named vice chairman of the board.

I. T. Meyer has been appointed plant manager of Industrial Rayon Corp.'s Covington, Va., plant succeeding **Lester R. Carrier** who has retired.

Paul J. Welsh has joined the research staff of E. F. Houghton & Co., Philadelphia.

Leonard Schaeffer has been appointed senior chemist in the products development laboratory at the Arco Co., Cleveland.

H. Z. Lecher, associate director of research, has been named director of research of the Calco Chemical Division, American Cyanamid Co., Bound Brook, N. J., in a consolidation of research, process development and dyes technical service into a single department. **Mario Scalera** is appointed assistant director of research and **R. P. Parker,** assistant director of research, will be in charge of pharmaceutical research section. **R. H. Kienle** and **A. L. Peiker** are appointed, respectively, director and associate director of application research embracing fundamental and applied physical chemistry. **M. L. Crossley,** director of Calco's research department is retiring in August 1949.

Chester F. Moculeski has been appointed to the technical service staff of the Chicago branch of the Glyco Products Co.

William H. Lycan has been appointed director of research of Johnson and Johnson, New Brunswick, N. J. He succeeds **David F. Smith,** who recently resigned.

(Continued)

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Meet a man who "works" in dozens of industries.

Right now he's engaged in compounding a special adhesive. Perhaps tomorrow he'll be working on a spray-on sound deadener. The next job might be a sizing, a saturant, a laminant, or a coating.

But whatever the job, it has this in common with all the others. The resulting product will be developed *with given characteristics to meet certain established requirements.*

Are you looking for an asphalt, resin, rubber or latex compound to take its place in your manufacturing process? Or do you want one for recombining? Whichever it is, he can help you.

And for "plant protection," you can't do better than Flintkote Protective Coatings. These specialized products are available in many forms to meet requirements for corrosion-protection . . . waterproofing and dampproofing . . . insulation coating . . . and many other important jobs around your plant.

Get complete information on the Flintkote line. We'll be glad to recommend a standard product to meet your needs, or to work with you to develop something to meet unusual requirements. Mail the coupon or write our nearest office.

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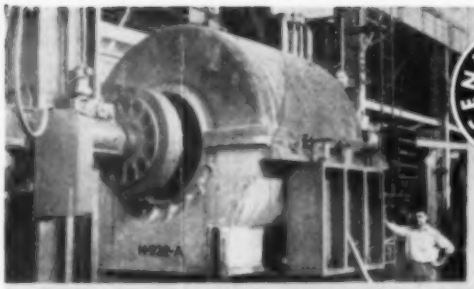
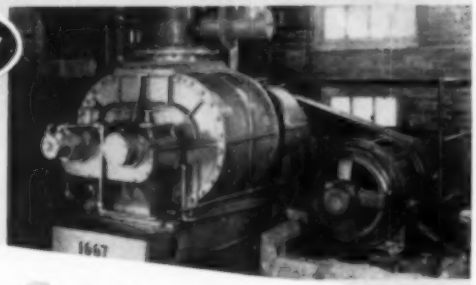


R-C Centrifugal Blower, with capacity of 69,300 CFM, being built in our plant.

ROTARY



R-C Rotary Blower, type RCD, capacity 6,200 CFM.

LET R-C dual-ability SETTLE THE QUESTION

If you are in doubt about whether Centrifugal or Rotary Positive units will do the best job of handling gas or air on any specific application, you can obtain an unbiased answer from R-C *dual-ability*.

Because we build both types, in wide ranges of sizes and designs, we can make sound comparisons and can recommend without prejudice the units whose capacities, pressures, drives and other characteristics deliver the best performance.

Only Roots-Connersville gives you this *dual choice*. It comes from 95 years of designing and building gas and air handling equipment, exclusively.

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BLOWER BUILDERS R.C. SINCE 1854

BLOWERS • EXHAUSTERS • BOOSTERS • LIQUID AND VACUUM PUMPS • METERS • INERT GAS GENERATORS

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OBITUARIES

William Richter, 62, former general manager of the fabrics and finishes department of E. I. du Pont de Nemours & Co., died in Philadelphia March 20.

Walter B. Brown, 74, president, Victor Chemical Works, Chicago, Ill., died of a heart ailment in Chicago March 21

Harvey C. Rentschler, director of Westinghouse lamp and electronic tube research until his retirement in July 1947, died at his home in East Orange, N. J., on March 23.

Charles B. Mead, 58, former general manager of the Mead Corp., Kingsport, Tenn., died in Florida March 24.

Clifton Slusser, 56, vice president of the Goodyear Tire & Rubber Co. since 1926, died in Akron March 25.

Frank H. Stohr, 47, general manager of the Allis-Chalmers Manufacturing Co.'s Norwood (Ohio) works, died March 29.

Raymond N. McAdams, former secretary of Hercules Powder Co., died in Wilmington, Del., April 9.

W. H. Dow

Willard Henry Dow, 52, died in Canada, March 31. Dr. Dow, his wife, Martha Pratt Dow, and three associates were killed in the crash of their plane near London, Ontario.

Willard H. Dow was born in Midland, Mich., Jan. 4, 1897; attended Midland schools; received his B. S. in chemical engineering from the University of Michigan at the age of 22; joined his father's Dow Chemical Co. after graduation. He was president, general manager and chairman of the board at the time of his death. He was a director of six other Dow affiliates; a member of AIChE and numerous other technical organizations; a 33rd degree Mason as well as a member of several other fraternal organizations.

Dr. Dow had received numerous awards in recognition of his services to American chemical industry.

Dr. and Mrs. Dow are survived by their son and daughter and two granddaughters.

SIDE ENTRANCE MIXERS
½ to 25 H. P. Sizes
Repacked from outside
MIXERS AND KETTLES
Complete with Tank and Drive Unit, in various types and sizes With any style stirrers, propellers or turbine
RIBBON MIXERS
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MAINTENANCE CREW HANDS OFF! -- it's a SIER-BATH ROTARY PUMP

Sier-Bath Screw Pumps and Gearex Pumps are designed to do a job—and keep doing it. The manufacturer has a full appreciation of the high cost of interrupting the operation of a line to permit pump repairs. On the Internal Gear-type Screw Pump, for example, the gland is the only point of attention and as this is on the suction side, it is almost negligible. It is not unusual for the packing to last two years without repacking. The pressure on the gland is so slight that it is possible to add a new ring of packing without shutting down the unit. Send for information.

ALSO MAKERS OF SIER-BATH PRECISION GEARS

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Sier-Bath GEAR and PUMP CO., Inc.

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INDUSTRIAL NOTES

Wright Mfg. Co., Houston, has announced an expansion which involves the construction of a new $2,000,000 manufacturing plant on Post Oak Road in Houston. This new addition was scheduled to open in April and will more than double the company's manufacturing capacity.

Lion Oil Co., El Dorado, Ark., has proposed for the consideration of its stockholders an amendment to its articles of incorporation increasing the authorized capital stock of the company to five million shares without nominal or par value and splitting outstanding stock on the basis of two shares for each share outstanding on the effective date of the amendment.

Chicopee Mfg. Corp., Cornelia, Ga., has completed construction of a 10,000-sq. ft. addition to the main plant of its Lumite division at Cornelia.

New Wrinkle, Inc., and **Chadeloid Corp.**, both of Dayton, have elected Robert F. Ohmer as their president.

E. I. du Pont de Nemours & Co., Wilmington, has reorganized and relocated the sales department of the industrial division of its plastics department. Sales will be handled only through three main regional offices in New York, Chicago and Los Angeles.

Pennsylvania Flexible Metallic Tubing Co., Philadelphia has appointed James R. Derrick assistant sales manager.

Kramer Trenton Co., Trenton, N. J., has appointed A. Robert Tankle direct factory representative in New York State.

Black, Sivalls & Bryson, Inc., Kansas City, Mo., has added James R. Banks to its staff of sales engineers, to be stationed in New Orleans, La. C. W. Hayes has taken temporary charge of the sales office in New Orleans. Floyd C. Myers, re-

(Continued)

Depend on AUTO-LITE FOR TEMPERATURE INDICATION

Dependable temperature indication by Auto-Lite points the way to many savings in manufacturing and storage operations. It is sensible economy to have one of these low-priced accurate thermometers wherever temperature is an important factor. Write for folder describing the many types and styles of Auto-Lite Thermometers, dial sizes, temperature ranges and prices.

Model F-1 Thermometer priced from $22. Choice of Temperature Ranges.

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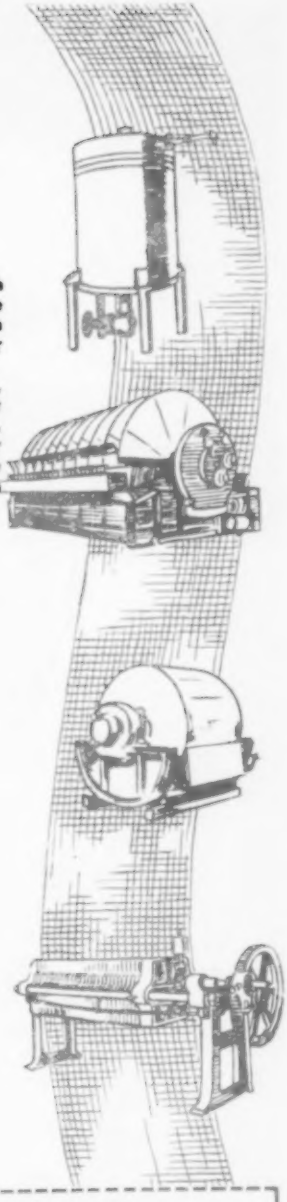
INDICATING & RECORDING THERMOMETERS

FEinc *Announces*

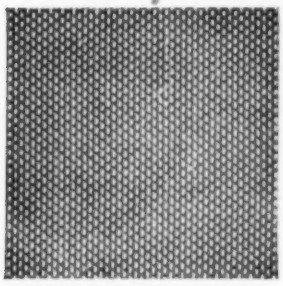
NEW LONG-LIFE FEON FILTER CLOTHS OF NYLON AND OTHER SYNTHETICS FOR ALL MAKES OF FILTERS

Culminating several years of research, during which time many different weaves of cloth were formulated and tested, Filtration Fabrics Div., Filtration Engineers, Inc. now announce a complete line of synthetic filter cloths—including Nylon, Orlon, and Vinyon N—with complete facilities for tailoring these new materials to fit any make of rotary vacuum or pressure filter or filter press.

These new synthetics are remarkably resistant to acids, alkalies, and bacterial action, last many times the life of previous fabrics. They save not only in replacements costs, but also in the expense of "down time" required for regular changes of ordinary cloths. Since they are stronger and more resistant to abrasion and mechanical abuse, a lighter cloth (which is usually found to be more efficient than a heavier cloth) can often be selected. Woven to give the best possible combination of filtering qualities with maximum life and minimum blinding or plugging up, they are remarkably easy to clean.

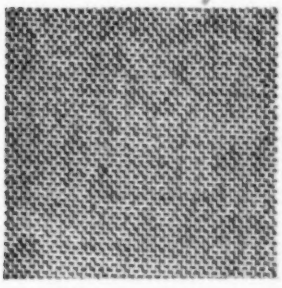


FEON *Nylon* FILTER CLOTHS



Unusually high breaking and tear strength, even at elevated temperatures. Tough, durable. Excellent abrasion resistance. Unaffected by most alkalis and organic acids, strong sodium hydroxide solutions, acetic acid, formic acid, and common solvents such as benzol, carbon disulfide, carbon tetrachloride, and trichloroethylene. Not recommended for strong mineral acids and oxidizing agents. Many weaves available.

FEON *Vinyon N* FILTER CLOTHS



New, Improved Vinyon N is highly resistant to practically all acids, alkalis, and most solvents. Includes concentrated hydrochloric acid, concentrated phosphoric acid, and concentrated sodium hydroxide. Not seriously affected by strong oxidizing agents. Excellent for *hot* acids. Many weaves available. A third material—strong FEON Orlon, has excellent resistance to strong mineral acids. Unharmed by common solvents, oils, greases, and acid solids.

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Designers and manufacturers of all types of storage, refrigerating, and processing equipment for the milk, food and chemical industries.

Products may be mixed, heated, cooled, and stored in this 200 gallon Chicago Stainless tank

COST-REDUCING EQUIPMENT
—at a competitive price

Like many others, you can cut costs . . . and . . . increase profits by modernizing with Chicago Stainless processing equipment. Every unit custom built — at a competitive price. You'll get exactly what you want without spending one dollar extra. Get a quotation from Chicago Stainless —TODAY. No obligation, of course.

Here are just a few of the various types of equipment made by Chicago Stainless:

- Refrigerating Tanks
- Storage Tanks
- Chemical Processing Tanks
- Steam Jacketed Kettles
- Food Processing Tanks
- Transportation Tanks
- Reaction Kettles

CHICAGO STAINLESS EQUIPMENT CORPORATION
3001 ELSTON AVENUE CHICAGO 30, ILLINOIS

gional sales manager, has transferred headquarters from the company's branch at Lubbock to Midland, Tex. John T. Cross, Jr., has been made branch manager at Hobbs, N. M. Benjamin W. Bourne, has been transferred to the Midland, Tex., sales office. A new sales office has been opened at Magnolia, Ark., under the direction of Raymond D. Canada.

Magna Manufacturing Co., Inc., New York, has announced the association of its Texas representative, A. M. Russell, with Scientific Supply Co., Houston, Tex.

Chicopee Manufacturing Corp., Ga., has elected J. F. Nicholl vice president and a member of the board of directors. G. H. Day II has been elected vice president.

Hilton-Davis, Cincinnati, Ohio, has made test runs at its new beta napthol plant.

General Electric Co., Schenectady, has expanded repair, maintenance and warehousing facilities in Salt Lake City, Utah.

Kiclev & Mueller, Inc., North Bergen, N. J., has appointed The Richard Barthlemess Sales Co., Jacksonville, as its exclusive sales representative in Florida.

Link-Belt Co., Chicago, Ill., has named Roy E. Jones export manager of the company with headquarters in New York.

Dorr Co., New York, has appointed Sociedade Tecnica e Comercial Serva Ribeiro S/A, Sao Paulo City, its exclusive representative in Brazil.

Union Carbide and Carbon Corp., New York, has combined the laminating and the adhesives division of the thermosetting department of its subsidiary, Bakelite Corp. The result of the merger will be known as the laminating and adhesives division. Harry Carlson has been appointed manager and J. L. Rodgers becomes assistant manager.

Hollingsworth and Whitney Co., Mobile, Ala., plans a $10,500,000 expansion program at its paper mill.

F. H. McGraw & Co., New York, has elected Urban D. Gosselin to its vice presidency. Harry W. Mathews

(Continued)

Temperature control demands
EAGLE-PICHER
Insulations

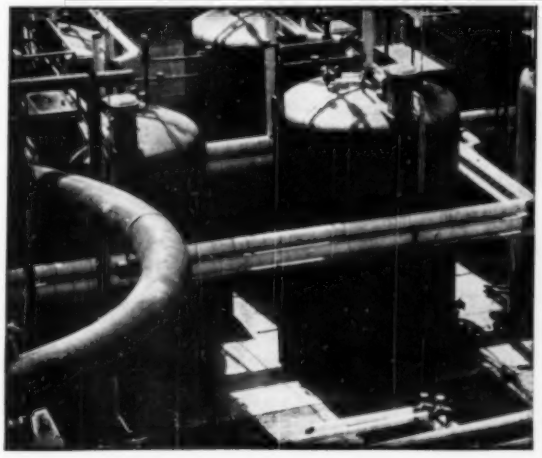
Eagle-Picher Super "66" Insulating Cement

for permanently efficient, economical installation!

"Springy Ball" pellets of Eagle-Picher Mineral Wool give Super "66" tremendous insulating efficiency. Each pellet contains heat-saving dead air cells that remain after the insulation dries to preserve *permanent* low thermal conductivity. In addition, Super "66" actively inhibits rust on metal equipment. It's all-purpose, sticks to any shape surface, and withstands temperatures up to 1800 F. Complete technical and application data on request.

Let these Eagle-Picher products also save you money... power... time

Insulating Felts
Superlemp Block • Blankets
Loose Wool • Pipe Covering
Stalastic • Insulseal • Insulstic
Swetchek • Finishing Cements
Insulating Cements



EAGLE-PICHER INSULATIONS for

EAGLE EP PICHER

High and low temperature

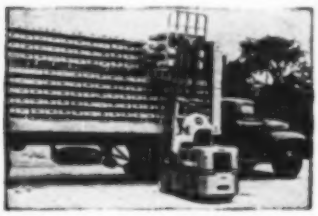
Since 1843
THE EAGLE-PICHER COMPANY
CINCINNATI (1), OHIO

MATERIAL HANDLING News

Handling costs quickly dropped 50 per cent in the Flint yard of J. P. Burroughs and Son, Inc., when Clark fork-lift trucks were installed. Even in unexpanded facilities, 33 per cent more materials are handled with ease.

A new warehouse *designed for modern materials handling*, and Clark electrics to do the work, cut handling costs 30 per cent for Associated Food Stores Cooperative, Inc., in New York. Savings benefited member stores instantly by enabling them to meet or beat competitors' prices.

Think of saving 75 per cent of the time required to unload a big trailer and reload it with fresh goods by the Clark method! That's the pleasant story told by Cleveland Coca-Cola Bottling Company. Clark machines perform other duties, too, at bottling plants and warehouses.



✓ Saved! 50% for a builders' supply yard

✓ Saved! 30% for a grocery warehouse

✓ Saved! 75% for a bottler

WHAT'S YOURS?

What's yours? How big is your own potential saving attainable through faster production, lower demurrage charges, fewer accidents, less damage and utilizing neglected "air rights" for live, profitable storage?

It costs nothing to *find out* how big a saving this potent cost-cutting principle can achieve for your business. Just CONSULT CLARK.

Useful reading—write for the current issue of Material Handling News.

CLARK ELECTRIC AND GAS POWERED FORK TRUCKS AND INDUSTRIAL TOWING TRACTORS

INDUSTRIAL TRUCK DIV., CLARK EQUIPMENT COMPANY BATTLE CREEK 8, MICH.
REPRESENTATIVES IN PRINCIPAL CITIES THROUGHOUT THE WORLD
AUTHORIZED CLARK INDUSTRIAL TRUCK PARTS AND SERVICE STATIONS IN STRATEGIC LOCATIONS

INDUSTRIAL NOTES, *cont* . . .

has become assistant to the president and Frank J. McClean, controller.

Sun Oil Co., Philadelphia, Pa., has announced a gross operating income for 1948 to be $447,309,191 for itself and its subsidiaries. Net earnings totaled $42,853,839.

Askania Regulator Co., Chicago, Ill., has appointed Wilson W. Wheeler sales manager.

Glidden Co., Cleveland, Ohio, has selected Ralph G. Golseth a director of the company.

Wyandotte Chemicals Corp., Wyandotte, Mich., has acquired about 200 acres of land at Dilles Bottom, Ohio. No immediate construction is contemplated but the new site was acquired for future additions to the corporation's organic chemical facilities.

Rose Polytechnic Institute, Terre Haute, Ind., has formed an industrial advisory board to the chemical engineering department.

Givaudan Corp., New York, has recently built a plant for the manufacture of perfume raw products in Delawanna, N. J. Wigton-Abbott Corp., Plainfield, N. J., handled the construction.

American-Marietta Co., Chicago, has elected A. King McCord to its board of directors in addition to re-electing the directors who previously served.

Proportioneers, Inc., Providence, R. I., has sent a new demonstration trailer to exhibit its constant rate and flow responsive proportioning machines throughout the southeastern states.

Godfrey L. Cabot, Inc., Boston, has appointed Delacour-Gorrie Ltd. as its exclusive representatives for the sale of carbon black and pine distillates throughout Canada.

Chase Bag Co., Chicago, has appointed James W. Wells sales manager of its Portland, Ore., branch. R. V. Bradley has been made sales manager of its eastern paper bag division, with offices in New York.

United States Steel Corp., Chicago, has appointed Charles V. Masterson, Jr., superintendent of industrial relations of the Gary (Ind.)

(Continued)

Sure Cure for gas or liquid leaks

No. 304-N Sylphon Packless Valve comes in sizes from ½" to 2" for pressures up to 150 lbs. Also available in larger sizes is No. 1304 with flanged connections for liquid pressures up to 80 lbs. No. 304-NV is ideal for vacuum service.

SYLPHON packless valves

● Even tiniest leaks of valuable liquids or gases are *stopped*—with Fulton Sylphon Packless Valves. Installed on pipe lines carrying oil, gasoline, or other volatile liquids or vapors, these valves prevent waste—provide vacuum protection. They guard you and your equipment against costly losses, explosion, fire, and other damage.

The valve has a dual-ply, seamless Sylphon metal bellows instead of the customary packing—eliminating leakage that can seep past the stuffing box of an ordinary packed type valve. The bellows provides a positive seal—is metal-housed for protection against erosion. Available in many sizes and types with body made of brass, bronze, cast iron, cast steel, stainless steel or monel.

Widely used in chemical plants, oil refineries, power plants, aboard ships—or wherever steam, air, gases or liquids are handled. For complete information, please write for Bulletin JC-813.

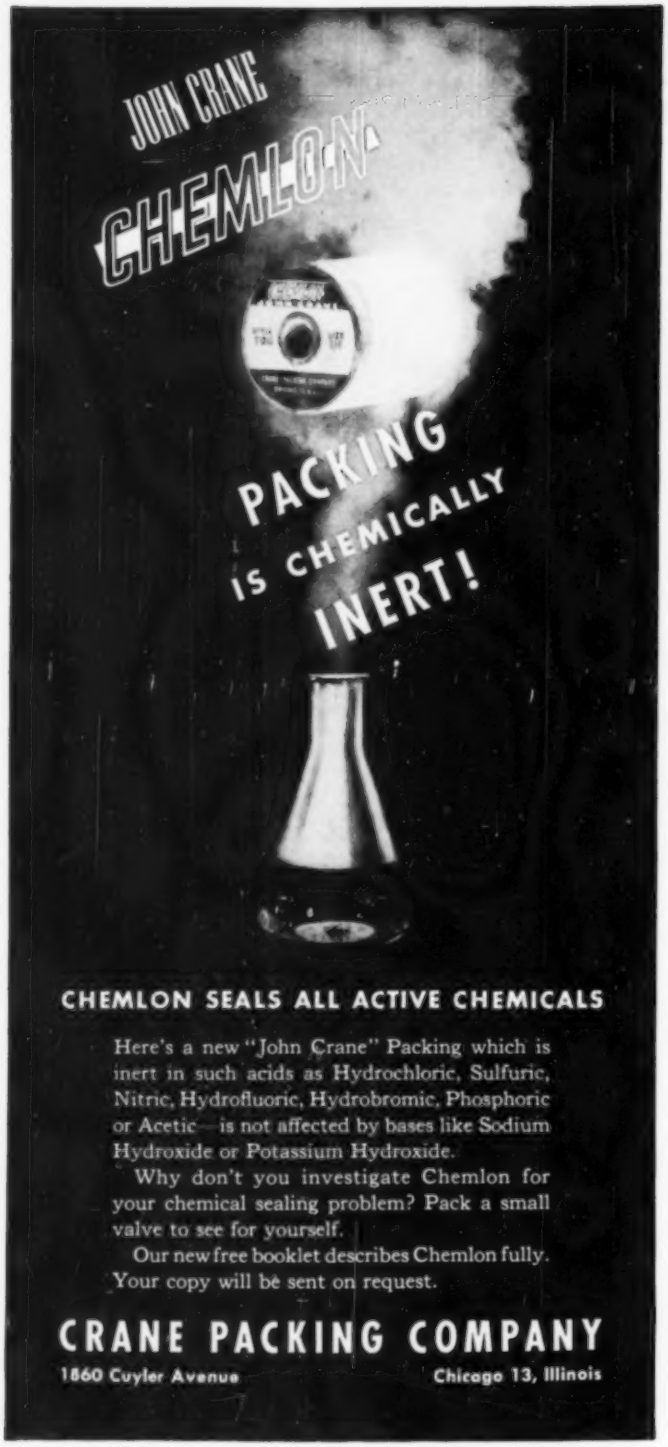
FIRST WITH BELLOWS

Temperature Controls • Bellows Devices • Bellows Assemblies

FULTON SYLPHON
DIVISION

ROBERTSHAW-FULTON CONTROLS CO., KNOXVILLE 4, TENN.

Canadian Representatives, Darling Brothers, Montreal



CHEMLON SEALS ALL ACTIVE CHEMICALS

Here's a new "John Crane" Packing which is inert in such acids as Hydrochloric, Sulfuric, Nitric, Hydrofluoric, Hydrobromic, Phosphoric or Acetic—is not affected by bases like Sodium Hydroxide or Potassium Hydroxide.

Why don't you investigate Chemlon for your chemical sealing problem? Pack a small valve to see for yourself.

Our new free booklet describes Chemlon fully. Your copy will be sent on request.

CRANE PACKING COMPANY

1860 Cuyler Avenue — Chicago 13, Illinois

INDUSTRIAL NOTES, *cont* . . .

sheet and tin mill of its subsidiary, Carnegie-Illinois Steel. He succeeds William P. Jones who has been transferred to Pittsburgh to become supervisor of education and training for Carnegie-Illinois.

Timken Roller Bearing Co., Canton, Ohio, has appointed M. S. Downes general sales manager of the railway division. J. E. McCort has been made assistant general sales manager of the division. Ralph G. Harmon has become district manager of the firm's industrial steel and tube divisions in Birmingham, Ala.

A. E. Staley Mfg. Co., Decatur, Ill., has added Dale T. Bush to its industrial products sales staff.

Texas Co., New York, has rigged up a single cylinder aircraft test engine with an unusual set of control instruments in its Beacon, New York, laboratories to establish the anti-knocking qualities of aircraft engine fuels.

Kennametal Inc., Latrobe, Pa., has moved its New York office to 11 West 42nd St. In its Cincinnati office C. Russell Miller has been appointed as a service engineer. Henry B. Worthington has been made sales engineer in the Springfield, Mass., office and Thomas J. Kniff, Jr., application engineer in the Philadelphia office.

Mason Regulator Co. of Canada Ltd., Montreal, Canada, has changed its name to Mason-Neilan Regulator Co. Ltd.

G-V Controls, Inc., with offices at 28 Hollywood Plaze, East Orange, N.J., has been organized to engage in the development and manufacture of electrical control equipment. President of the new company is C. D. Geer.

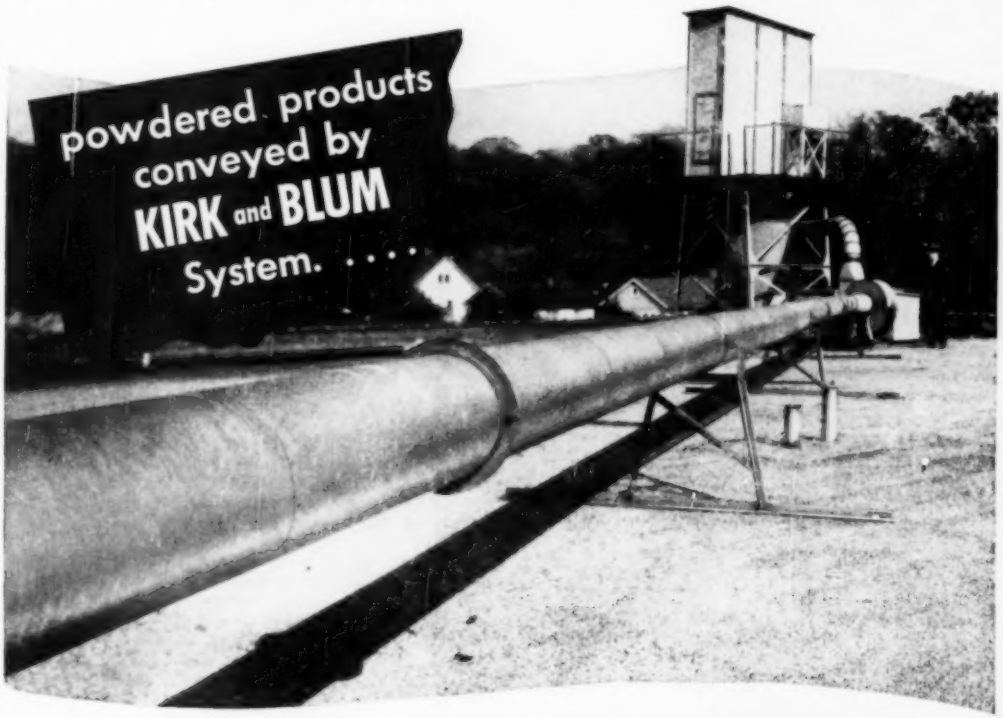
Goodyear Tire & Rubber Co., Akron, Ohio, has appointed Campbell Industries, Inc., Mahomet, Ill., as its middle west distributors of Pliobond, an all-purpose adhesive.

Bemis Bro. Bag Co., St. Louis, Mo., has elected H. P. Claussen a member of the board and C. W. Loomis vice president.

H. J. Heinz Co., Pittsburgh, has named Charles A. John head of its crop research department at its experimental farm and plant breed-

(Continued)

"RIDING ON AIR"



The economical transportation of bulk powders and the collection of harmful *or* valuable dusts, are just a few of hundreds of jobs performed by KIRK & BLUM equipment in leading chemical and process industries plants.

Through this system, illustrated above, powdered drugs are conveyed 500 feet. Even longer distances may be served.

Backed by more than 40 years of experience, KIRK & BLUM is equipped to design, fabricate *and* install specialized equipment to eliminate your particular problem. To architects, contractors, plant engineers and owners, KIRK & BLUM service means undivided responsibility . . . one contract for the system, installed, ready and guaranteed to operate. The KIRK & BLUM MFG. CO., 2908 Spring Grove Ave., Cincinnati 25, Ohio.

Send for these booklets: "Fan Systems for Various Industries", "Industrial Ovens".

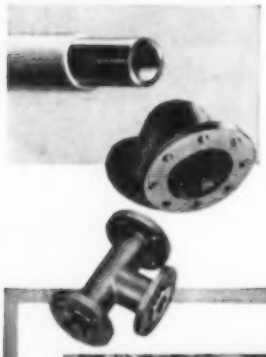
For the same noted pharmaceutical manufacturer, KIRK & BLUM designed and installed this system which delivers finely ground materials to mixing drums. Up to 3000 lbs. of powder is handled per hour without loss to outside atmosphere.

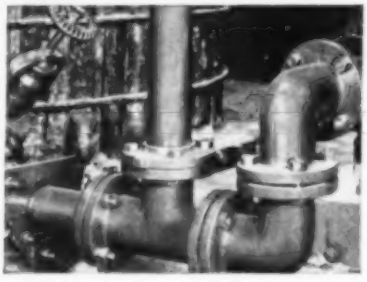
FOR CLEAN AIR . . . THE [redacted] *TOOL*

KIRK AND BLUM

AIR HANDLING SYSTEMS — DUST & FUME CONTROL

saran lined steel pipe





resists corrosion

- reduces shut-downs and lost production!
- saves time and labor!
- readily field-fabricated!

The conveyance of corrosive liquids can prove as hard on profits as it is on equipment. Saran Lined Steel Pipe is designed and constructed to protect YOUR profits. It combines the desirable features of steel pipe—rigidity and pressure strength—with Saran's unusual resistance to most corrosive chemicals, solvents, and erosion. Another advantage is ease of field fabrication. For general service, Saran Lined Steel Pipe can be used at temperatures between —40° and 190°F.

Saran Lined Steel Pipe comes in maximum lengths of 10 feet and in sizes from 1 to 4 inches. Plug valves and fittings, also Saran Lined, include elbows, tees, companion and reducing flanges, and gaskets. AVAILABLE IMMEDIATELY. Write us today for further information concerning Saran Lined Steel Pipe and how it can solve your problem. Manufactured by The Dow Chemical Company, distributed nationally by Saran Lined Pipe Company.

SARAN LINED PIPE COMPANY
702 Stephenson Building
Detroit 2, Michigan

Offices in: New York • Boston
Philadelphia • Pittsburgh • Chicago
Tulsa • Indianapolis • Houston
San Francisco • Los Angeles
Portland • Seattle • Toronto
Denver • Cleveland

DOW
CHEMICALS INDISPENSABLE TO INDUSTRY AND AGRICULTURE

ing grounds at Bowling Green, Ohio.

Wagner Awning & Mfg. Co., Cleveland, Ohio, has been sold to its employees.

Banner Chemicals, Inc., Cleveland, Ohio, has been incorporated to manufacture rare chemicals for research work.

Link-Belt Co., Chicago, has appointed J. H. Oakes sales manager, enclosed drives, with headquarters at Philadelphia. He will be assisted by Harry F. Kurz as representative, enclosed drives, with headquarters at Chicago.

Industrial Process Engineers has moved into a new and larger plant at 8 Lister Ave., Newark, N. J. Plant and offices were previously located in West New York, N. J.

Edwal Laboratories, Inc., Chicago, has appointed George L. Wheeler, manufacturers' agent in Philadelphia, as its representative.

Hydraulic Press Mfg. Co., Mount Gilead, Ohio, has appointed J. P. Vederko works manager.

Monsanto Chemical Co., St. Louis, has appointed Charles H. Sommer to the new position of assistant to the vice president in charge of the coordination of the company's sales, advertising, and foreign department activities.

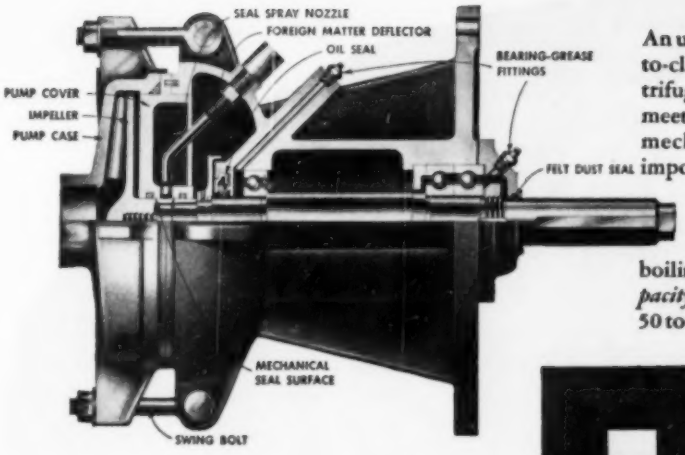
Multi-Metal Wire Cloth Co., Inc., New York, has elected Siegfried Stern chairman of the board. Mr. Stern is also president of the company.

Continental Can Co., Inc., New York, has begun construction of a plant for the manufacture of beer cans, food containers and bottle caps in Milwaukee, Wis.

Witco Carbon Co. and Continental Carbon Co., New York, have both elected H. B. Seligman vice president. Witco Carbon Co. has elected Max A. Minnig and John H. Wishnick directors.

Monsanto Chemical Co., St. Louis, has made Cyrus W. Merrell assistant general manager of sales for its organic chemicals division. Gerald F. Pauley has succeeded Mr. Merrell in charge of pharmaceutical sales in St. Louis. William M.

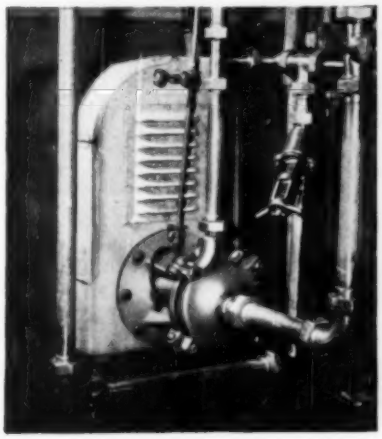
(Continued)



An unusually compact, easy-to-clean, selective speed centrifugal pump... designed to meet exacting sanitary and mechanical requirements imposed by food evaporation processes that operate under high vacuums and high boiling temperatures. *Capacity:* 20 to 100 gpm. *Head:* 50 to 200 ft. *Speed:* Selective.

The New BJ *Sanitary Food Process Pump*

This is one of a large number of BJ Sanitary Food Process Pumps installed by Golden State Co., Ltd. For standard application, pump is mounted on sturdy sheet-metal cabinet containing drive motor, as indicated. Selective Vee-belt drive provides for flexible adaptation to variable power and speed conditions. Discharge nozzle can be rotated to any one of four positions. If desired, pump is sold separately for special mounting.



CONVENIENT DISMANTLING AND CLEANING—Pump can be dismantled for cleaning with a few simple manipulations. Case is held by four swing bolts, impeller by a simple bolt threaded into impeller hub.

MECHANICAL SEAL—A simple, water-cooled-and-lubricated mechanical seal assures a trouble-free, easily cleaned stuffing box.

STANDARD SANITARY FITTINGS—Suction and discharge nozzles are machined to receive standard sanitary fittings.

STAINLESS STEEL—All parts that contact pumped liquid are of polished 18-8 stainless steel.

Byron Jackson Co.

LOS ANGELES 54, CALIFORNIA

Offices in Principal Cities

Fig. 2140
GLOBE
125 lb. S.P.
200 lb. W.O.G.

125 lb. S. P. BRONZE GLOBE, ANGLE and CHECK VALVES
Built to **LUNKENHEIMER QUALITY STANDARDS**

Want a lower pressure valve to give the same dependable, low-cost service you get in higher pressure LUNKENHEIMER Valves?

Here it is — New Fig. 2140 Globe; Fig. 2141 Angle; Fig. 2142 Lift Check; Fig. 2144 Swing Check. These valves feature Lunkenheimer's traditionally fine design and sturdy construction, plus exclusive silicon bronze alloy stems which eliminate stem thread failure due to wear.

Whatever your requirements for lower pressure service, you'll find these new valves unequalled for dependability and true economy.

Your LUNKENHEIMER DISTRIBUTOR is stocking these new 125 lb. S.P. Bronze Valves. Call upon him for your original equipment, replacement and repair valve requirements. Ask him for Circular No. 582 or write direct.

ESTABLISHED 1862
THE LUNKENHEIMER CO.
"QUALITY"
CINCINNATI 14, OHIO, U. S. A.
NEW YORK 13 · CHICAGO 6
BOSTON 10 · PHILADELPHIA 24
EXPORT DEPT. 318-322 HUDSON ST. NEW YORK 13, N. Y.

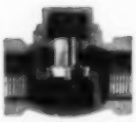


Fig. 2142 LIFT CHECK
125 lb. S.P. 200 lb. W.O.G.

Nowhere in the line is dependability more important than in Check Valves. These Checks function quickly and positively, seat accurately and tightly.

Fig. 2144 SWING CHECK
125 lb. S.P. 200 lb. W.O.G.

INDUSTRIAL NOTES, *cont* . . .

Russell has been made general branch manager of the division's sales office in Chicago.

General Electric Co. Schenectady, has appointed S. W. Corbin assistant manager of the industrial divisions of the apparatus department.

Link-Belt Co., Chicago, has moved its Spokane, Wash., warehouse to new larger quarters at North 1303 Washington St.

Kerotest Manufacturing Co., Pittsburgh, Pa., has appointed Kenneth F. Vilsack Chicago district sales representative.

Freeport Sulphur Co., New York, has elected John Hay Whitney chairman of the board of directors.

Sharp & Dohme Inc., Philadelphia, has announced that Henry W. Gadsden, its director of pharmaceutical production and engineering, has been named district chief of the Philadelphia Ordnance District.

United States Rubber Co., New York, has appointed G. Roger McNear assistant to its president.

Freeman Chemical Corp., Milwaukee, has been established to engage in the manufacture and sale of processed vehicles for paint, varnish and lacquer manufacturers.

A. O. Smith Corp., Milwaukee, has established a shop for production of heat transfer equipment in connection with its vessel division; P. A. Thompson has been made product supervisor.

Monsanto Chemical Co., St. Louis, has named Richard T. Clark branch manager of the New York sales office of its Merrimac division. He succeeds W. E. Drown who will go to Boston as assistant to a vice president of the New England Alcohol Co., a partly owned subsidiary of Monsanto. Harold E. Duston has been appointed assistant sales manager of the surface coatings department.

Bee Chemical Co., Chicago, has elected M. A. Self president. He will continue his duties as sales manager.

Tube Turns Inc., Louisville, has appointed A. B. Judd Supply Co., Houston, Tex., its distributor of welding fittings and flanges in the southwest.

(Continued)

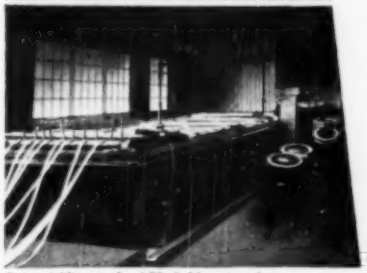
ACE HARD RUBBER AND PLASTICS

STOP CORROSION AT ALL VITAL SPOTS

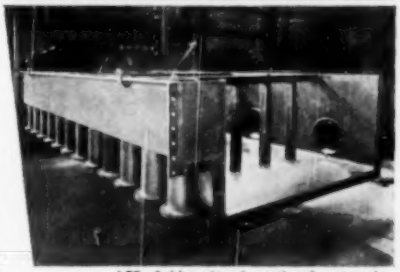
FOR INSTANCE

ACE HARD RUBBER LINED TANKS

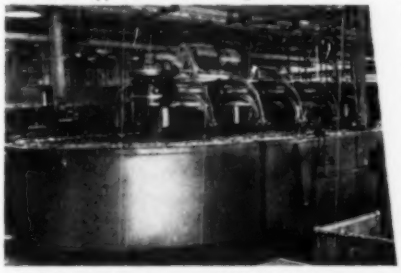
Ace hard rubber resists all alkalies, metallic salts of inorganic acids, hydrochloric acid any strength, nitric acid up to 16° Baume, phosphoric acid to 75%, sulphuric acid up to 50° Baume, most other inorganic acids any strength, and countless other corrosive solutions and fumes. Other Ace plastics such as Saran and Parian (polyethylene) extend this range of applications still further. Catalog 300-7 and Ace plastics bulletins tell you where Ace-clad and Ace molded equipment saves for you—send for them today.



Strip pickling tank, ACE Rubber Lined. Similar tanks several hundred feet long have been supplied with ACE linings.

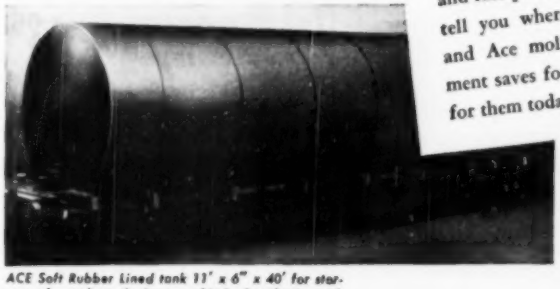


ACE Rubber Lined sectional processing tank. Unusual and intricate constructions can be lined or covered by ACE Process.



ACE Rubber Lined tank in automatic plating equipment. No current loss; permanent installation.

For heavy chemicals: ACE Rubber Lined processing tank with over-flow trough.



ACE Soft Rubber Lined tank 11' x 6" x 40' for storage of good grade (water white) phosphoric acid.

ACE Rubber Lined storage tank for the Paper Industry. Sectional construction for convenience in installing in an existing plant.

ACE SINCE 1851 AMERICAN HARD RUBBER COMPANY · 11 MERCER STREET · NEW YORK 13, N. Y.

649-H

"CARRYING"
..is part of school-day romance ..but it costs you money in manufacturing

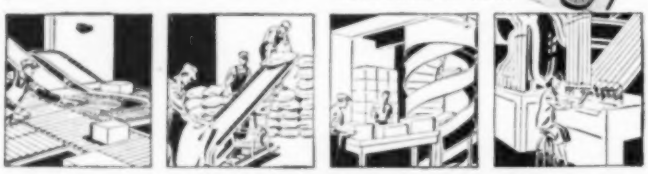
"CARRYING" commodities to and from production, assembly, processing or packaging lines costs too much. It's a waste of time and manpower.

Put conveyors to work "carrying" — packages, parts, units — loose or in containers — up, down, or across-through manufacturing or processing to storage or shipping. Speed handling operations—save time and costs.

The range, versatility, and flexibility of Standard Conveyors have been developed in more than 40 years of service to businesss and industry. See Standard for any conveyor need.

STANDARD CONVEYOR COMPANY
General Offices: North St. Paul 9, Minnesota
Sales and Service in Principal Cities

Send for Standard's General Catalog—see how conveyors are used to best advantage in every field of industry. Ask for Bulletin No. CM-59.



ROLLER • BELT • SLAT • CHAIN CONVEYORS • PORTABLE CONVEYORS AND PILERS • SPIRAL CHUTES • PNEUMATIC TUBE SYSTEMS

INDUSTRIAL NOTES, cont. . .

Lukens Steel Co., Coatesville, Pa., has made Edmund Pfeifer assistant district manager of sales of the Boston office.

General Electric Co., Pittsfield, Mass., has appointed Alan T. Wolcott manager of advertising and sales promotion and John A. Grove manager of marketing research for its chemical department. The chemical department has also initiated a new price protection policy to permit buyers of raw material in the paint industry to place orders with the assurance that inventories will not lose value before they are normally consumed.

Monsanto Chemical Co., St. Louis, has elected J. G. MacDermot a vice president. He is manager of the western division of Monsanto (Canada) Ltd. at Vancouver, B. C.

Tennessee Eastman Corp., Kingsport, Tenn., has appointed Wilson & Geo. Meyer & Co. as west coast distributors for its Tenox products, antioxidants for edible fats and oils.

Sherwin-Williams Co., Cleveland, has appointed Walter J. Boll as Gulf States zone representative for sales to transportation and petroleum trade.

McQuay Inc., Minneapolis, Minn., has reappointed the Halberg Co. as its heating and air conditioning representative in Brooklyn, Long Island, Staten Island and New York.

Olin Industries, Inc., East Alton, Ill., has appointed W. C. Schade manager of product divisions.

Commerce and Industry Association of New York, Inc. has elected George H. Coppers and John A. Hill to its board of directors.

Metalwash Machinery Corp., Irvington, N. J., has opened an office in Detroit, Mich., headed by Webb L. Nimick.

Lever Brothers Co., Cambridge, Mass., has elected James M. Elliott and Ralph P. Lewis to its board of directors.

United States Steel Corp., Chicago, has named Eugene G. Sheasby general staff manager, general sales division of its warehousing subsidiary, United States Steel Supply company.

(Continued)

CROUSE-HINDS

Arktite

Plugs and Receptacles are circuit breaking and SAFE without additional disconnect equipment.

Grounding pole is bonded to the receptacle housing.

Arktite Plugs and Receptacles are made in two styles. With either style the portable appliance is grounded before it is energized and remains grounded until after it is disconnected.

Arktite Style 1 is for use under conditions where it is acceptable to use the contact of the plug sleeve with the receptacle housing to complete the grounding safety circuit. The extra grounding conductor in the portable cable is bonded to the plug handle.

Arktite Style 2 (illustrated here) has an extra grounding pole which is protected against dirt and corrosion. This grounding pole forms a parallel circuit with the plug and receptacle housings and assures continuity of the grounding safety circuit under severe service.

Grounding conductor is bonded to the plug handle.

Arktite Style 2. Sectional View

Grounding pole is longer than the others so contact in the grounding circuit is made first and broken last.

The arc formed by pulling the plug is instantly snuffed in the confined insulated arcing chamber.

Each plug contact fits closely the opening of its individual arcing chamber.

The arc is broken while the plug contact is still a considerable distance inside of the arcing chamber. There is no danger of the arc traveling over to the other side of the circuit or to the housing.

Two-piece plug is easy to take apart and reassemble.

Direct-pressure clamp insures postive grip on the conductor cable.

The green line indicates the grounding safety circuit.

CROUSE-HINDS offers the only complete line of circuit breaking plugs and receptacles—20 Amp. to 400 Amp., 250 volt D.C., 600 volt A.C.

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INDUSTRIAL NOTES, cont . . .

Ehrhart & Arthur, Inc. has moved to 155 Montgomery St., San Francisco, Calif.

Stewart Hartshorn Co., New York, has appointed William R. Porter sales manager.

Glyco Products Co., Inc., New York, has transferred its Brooklyn manufacturing and research facilities to its main plant at Natrium, W. Va.

Marlow Pumps, Ridgewood, N. J., has appointed Andre S. Rubin, Jr., sales manager.

Rayonier, Inc., New York, has elected D. Samuel Gottesman to its board of directors.

Minneapolis-Honeywell Regulator Co., New York, has acquired the assets of the H. Belfield Co. in Philadelphia.

Vapor Recovery Systems Co., Los Angeles, has established a manufacturing affiliate in Paris, France. The affiliated company is Compagnie Technique des Petroles headed by Zarry Toula.

Sharp & Dohme Inc., Philadelphia, has named Elmer W. Metzger director of domestic branches and Don M. Robertson, products marketing manager.

Glidden Co., Cleveland, has appointed Z. G. Peck regional director of its Pacific coast paint and varnish division. Herman F. Winger has replaced him as acting regional director of the Adams & Elting division.

American Pipe and Construction Co. has appointed Arthur B. Smith manager of the southeastern district of its Amercoat division, with headquarters in Jacksonville, Fla.

Chas. Pfizer & Co., Inc., has moved its domestic sales department to the Brooklyn headquarters of the company.

Synthane Corp. of Oaks, Pa., has appointed Herbert W. Widdop sales manager. Eldridge E. Smith has been named assistant sales manager.

Food Machinery and Chemical Corp., Philadelphia, has appointed Carl E. Schaffer general sales manager of its subsidiary, Stokes and Smith Co. G. F. Twist has been appointed Stokes & Smith's division manager at Philadelphia. —*End*

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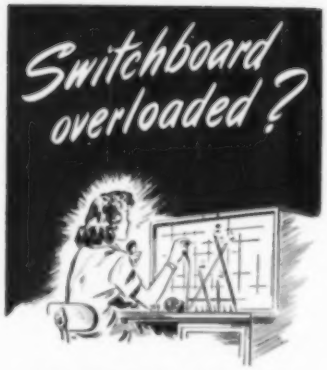

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CONVENTION PAPER ABSTRACTS

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RAYON

. . . *Fiber Skins*

Otto Goldschmid

A natural "sausage casing" on wood and cotton fibers adds greatly to the cost of rayon.

While wood and cotton fibers dissolve readily to form the viscose solution, a very minute portion always remains behind undissolved. Small as they are, the undissolved particles of cellulose would clog spinneret holes if they were not removed by a slow and expensive filtering step.

Seeking to determine why this troublesome residue fails to dissolve, tiny tufts of cellulose were examined under a microscope and watched while they were under attack by the dissolving chemicals. The difficulty was caused by a transparent fiber skin which split like sausage casing, shriveled into tiny wads, and kept grains of cellulose compressed so that they did not soak up chemicals.

Each fiber began to swell, but instead of swelling up evenly, the swollen fibers looked like strings of pearls or like balloons pinched off by constrictions at various intervals. The parts of the fibers that ballooned dissolved rapidly, but the constricted portions resisted the dissolving action.

Both cotton and wood fibers have

(Continued)

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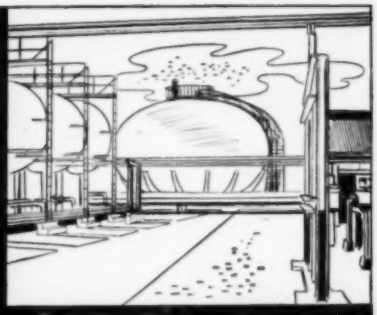

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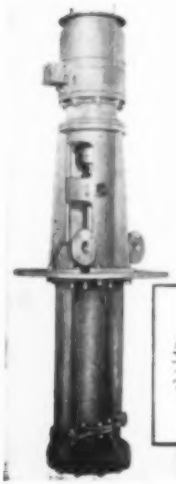

A newly-devised heating system circulates an abrasive-corrosive salt mixture at 850° F and even higher. To meet these tough requirements Lawrence engineers designed a vertical centrifugal pump with bearings and packing box outside the storage tank. An extra heavy shaft, in conjunction with dual opposed discharge outlets, minimize vibration and wear. All submerged parts are made of special alloys highly resistant to corrosion and abrasion of the hot mixture.

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a thick inner wall consisting of many layers of cellulose. It is known from x-ray studies that the cellulose molecules in these layers are arranged in a steep spiral along the center of the fiber. The outer wall of these fibers is a thin membrane like the skin on a sausage.

Normally the swelling and ballooning of the fibers is too fast to watch. However, it is possible to slow down the dissolving and to watch it occur in slow motion. The fibers twist on swelling, owing to the unwinding of the inner wall. The twisting motion of the fiber forces the outer skin, which has been split up lengthwise by the swelling, to wrap itself in the opposite direction around the swollen fiber.

As the swelling of the inner wall continues, the spiral becomes wrapped tighter and tighter around parts of the fiber, preventing them from swelling further. The tightly bound parts, between the balloons, could not dissolve because they were prevented from swelling by the knotted outer skin.

In order to give a perfectly clear viscose solution, the best possible kind for making rayon, the purification of the fibers should include a treatment which weakens the outer skin so that it cannot restrict the swelling of the fibers.

Otto Goldschmid, Rayonier, Inc., before Division of Cellulose Chemistry, American Chemical Society, San Francisco, March 31, 1949.

MATERIALS

. . . *Hydrogenation Steels*

George A. Nelson

Many important chemicals require processing in the presence of hydrogen at elevated temperatures and pressures at some stage. Damage caused by exposure of steels to high pressure hydrogen might be described as attack consisting of decarburization and intergranular cracking.

Attack by hydrogen is prevented by adding to the steel any of the carbide-stabilizing elements. In their order of importance they are: manganese, molybdenum, chromium, tungsten, vanadium, titanium and columbium. All the austenitic steels are resistant because of their high chromium content. The presence of impurities such as phosphides and sulphides has a tendency to increase attack; therefore, the total amount of these elements should be kept below the minimum required by ASTM specifications.

When corrosives other than hy-

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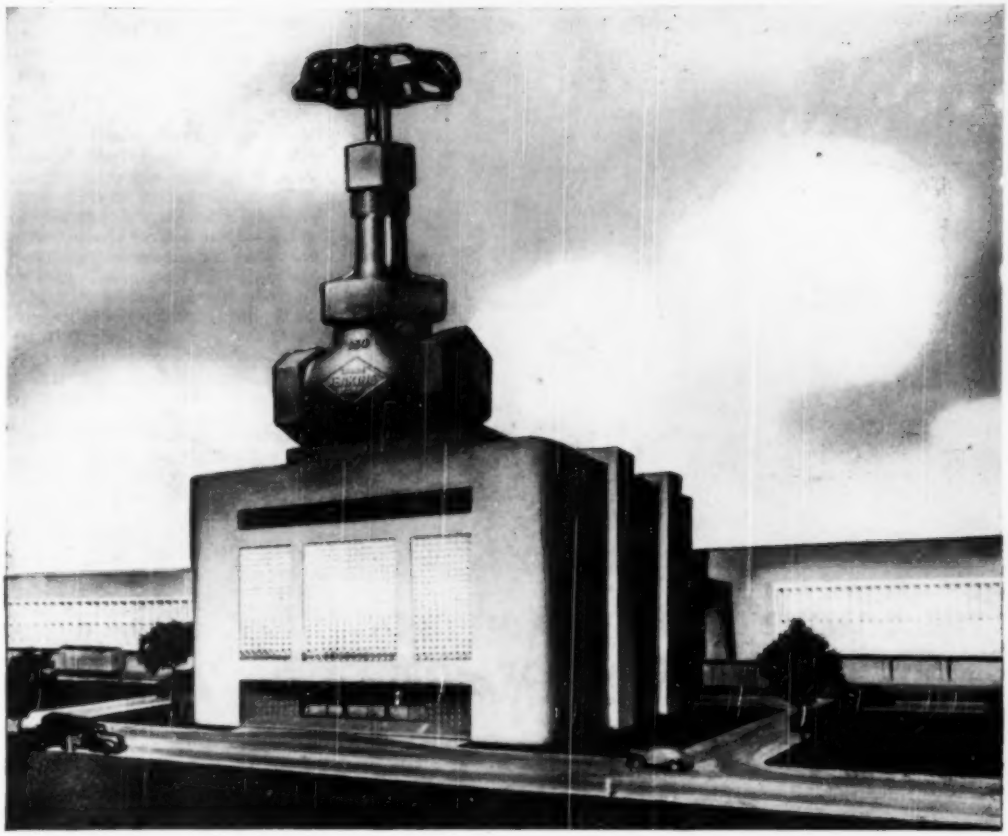

There's Truth in this "Tall Story"

IF YOU THINK of *all valves* in this plant as *one valve*, you'll see the truth in this trick photo. Valves, collectively, represent one of the biggest investments in equipment in any plant.

That's why, with wages and material costs higher than ever before, it is just as important to keep a sharp eye on valve maintenance as it is on operating costs of larger plant units.

EXCESSIVE MAINTENANCE of one inferior valve is insignificant, but, multiplied by thousands, it becomes a serious drain on operating budgets.

JENKINS BROS. helps you meet this problem two ways. First, by building extra endurance into Jenkins Valves, making them the longest-lasting, lowest-upkeep valves that money can buy. Second, with advice from Jenkins Engineers on any question of proper selection, installation, or maintenance.

For all new installations, for all replacements, rely on Jenkins quality and engineering service for lowest valve costs in the long run. *Sold through leading Industrial Distributors everywhere.*

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"PREVENT VALVE FAILURE" is a 28-page guide to valve economy, fully illustrated, with case histories of valve damage, and recommendations for its prevention by proper selection, installation, inspection, and maintenance. FREE on request. Write JENKINS BROS., 80 White St., New York 13, N. Y.

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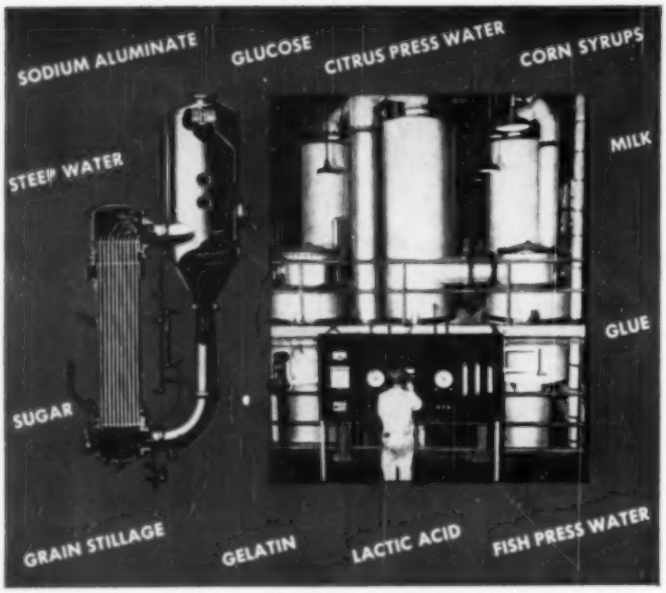

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TRADE MARK

drogen are in the process streams, the problem becomes more complicated, and additional measures may be required in order to fabricate apparatus that will be free from trouble. Experiences with sulphur and ammonia show that when sulphur is present, either as the element or as hydrogen sulphide, it has the ability to corrode either carbon steel or low-chromium steel when the temperature rises above 675 deg. F. The corrosion rate rises in relation to the amount of sulphur in the stream, and a definite recommendation cannot be made as to the amount of alloy required to resist the attack. For complete resistance to sulphide attack, the high-alloyed steels, such as 12 percent chromium or 18 percent chromium—8 percent nickel, are required. These metals are frequently used as liner materials for reaction vessels and exchangers.

In the case of ammonia it has been found that nitriding begins at temperatures above 850 deg. F. This nitriding is typified by a thin, hard brittle line, and occurs on steels containing more than 2 percent chromium. For protection against nitriding, an alloy containing 16 percent chromium, 15 percent nickel, 3 percent silicon and 0.4 percent carbon has been reported as satisfactory at 950 deg. F. and 12,000 psi. It is also understood that a high-nickel alloy containing 57 percent nickel, 12 percent chromium and 1.7 percent tungsten is used for converters in the Claude process of synthesizing ammonia. The life varies between 2,000 and 20,000 hr. depending on the quality of the casting.

George A. Nelson, Shell Development Co., before 14th Midyear Meeting, American Petroleum Institute, Houston, Apr. 4-7, 1949.

INSECTICIDES

. . . *Improvements Needed*

W. H. Tisdale & J. W. Williams

Despite the enormous progress of recent years in the insecticide field, there is still a great need for more efficient and safer chemicals. There is much room for improvement in some of the most commonly used products. There are still some important insect pests for which there are no satisfactory chemical controls.

Acute toxicity tests should be made in the early stages of development of a new chemical, to protect the chemist and his associates from any possible hazards during their research. Even if no symptoms of poisoning occur, the product should be handled with reasonable care until the more important chronic toxity studies can

be conducted. These are expensive, and as a rule are not considered necessary until it is reasonably certain that the product will be put into use. At this stage, of course, the question of public health becomes an important factor, and adequate toxicological studies should be made to permit effective instructions for safe use to be included in all directions.

Fortunately, a few very promising insecticides with a wide range of utility have been discovered, an outstanding example, being methoxychlor, a cousin of DDT which is far less toxic to warm-blooded animals.

Wendell H. Tisdale and Jonathan W. Williams, E. I. du Pont de Nemours & Co., before Division of Agricultural and Food Chemistry, American Chemical Society, San Francisco, March 30, 1949.

MARKET DEVELOPMENT

. . . *What's It Good For?*

R. H. Ewell

"What is new chemical X good for?" is the perennial question which chemical managements are always asking their research and sales departments. This question paraphrases the well-known question put to Michael Faraday, but in contrast with the tempo of Faraday's time, chemical managements hope and expect to have the answer in less than a generation or two. In many companies, the answer to this question is the function of the sales development department which bridges the gap between the research department and the sales department.

There are two basic approaches to the discovery and development of uses for new chemicals:

Study of the chemical and physical properties of the new chemical—with what other chemicals will it react, what substances will it dissolve, what are its effects on plants and animals, etc.?

Scrutiny of the end uses of present large-scale chemicals in terms of the necessities and luxuries of life.

If these two approaches can be made to meet in the middle, the foundation will have been laid for large-scale exploitation of the new chemical.

To the three classical necessities of life—food, clothing, and shelter—there have been added during the past century two additional necessities, transportation and communication, and medicine and hygiene. In addition, many luxuries, such as tobacco, cosmetics, toilet preparations, photographic materials, and others have reached a size and stability of demand in the modern world nearly equal to that of necessities. It is to these large groups of necessities and luxuries that

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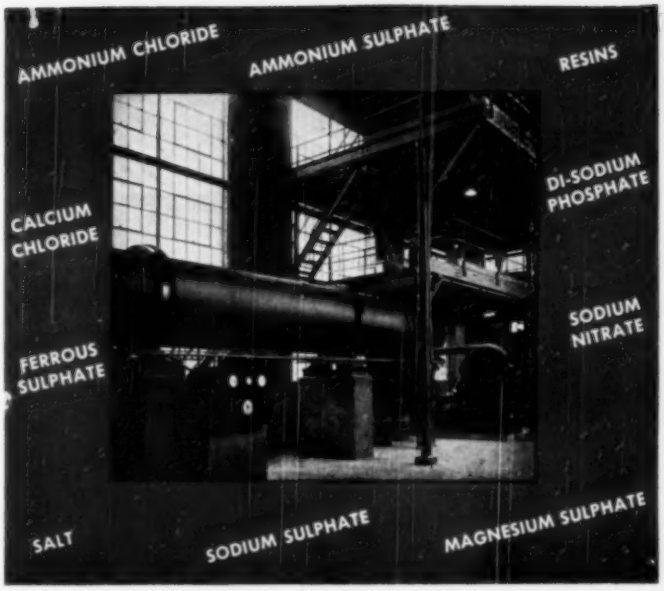

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chemical manufacturers must look for large-scale outlets for new chemicals.

Raymond H. Ewell, Stanford Research Institute, before Division of Industrial and Engineering Chemistry, American Chemical Society, San Francisco, March 30, 1949.

AIR POLLUTION

. . . Eye Irritation

P. L. Magill

The smog of Los Angeles is unique in that it sometimes produces severe and disagreeable eye irritation. In common with the smog in other parts of the country, however, it also imparts a murkiness to the atmosphere. Eye irritation is severe on only some 20 occasions during a year, and then in only limited areas and for relatively brief periods of time. Reduced visibility in connection with smog occurs very much more frequently.

The peculiar meteorology of the Los Angeles area appears to be decisive in controlling the time and duration of eye-irritating smog. Studies of meteorological influences have revealed an empirical correlation between certain meteorological factors and the time of occurrence of eye irritation from smog. This correlation may be useful in forecasting such smog.

The nature of the substances in smog that cause the eye irritation is not yet known. Work on this problem is currently progressing by the invention of improved ways to collect and identify the particles that compose smog, and by determining, under laboratory conditions, the eye-irritating properties of these substances in various aerosol forms when present in a specially-built "smog chamber."

Paul L. Magill, Stanford Research Institute, before Division of Industrial and Engineering Chemistry, American Chemical Society, San Francisco, March 28, 1949.

COLLOIDS

. . . Textile Processing

E. I. Valko

Almost the entire field of wet processing of textiles is in the domain of colloid science, as it involves phenomena at interfaces between fibers or yarns and aqueous solutions. Therefore, the mechanism of many wet processes invites interpretation in terms of classical colloid chemistry. Where, however, a so-called internal interface is the site of the phenomena,—that is, where the amorphous portion of the fiber is penetrated by at least partly molecular or ionic solutions (as in the case of many dyeing operations)—the classical colloid interpretation needs to be replaced by more adequate treatments.

(Continued)

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CONVENTION PAPERS, cont. . .

Topologically, we have to distinguish between finishing processes affecting the surfaces of yarns, the surfaces of fibers, the amorphous portion of the fiber, and finally the whole fiber substance. These processes aim either at an addition, a modification, or the removal of a substance from the textile. Compounds added to facilitate textile processing have to be easily removable, whereas a finish should be as durable as possible. For the latter purpose use is made of the principles of adsorption, insolubilization by chemical reaction, and mechanical trapping. Reaction with the fiber molecules is a special case of insolubilization by chemical reaction. Two or all three principles may be combined to achieve satisfactory fixation.

A fair understanding of the mechanism of finishing processes has been attained in spite of their complexity through the knowledge of the degree of dispersion of the finishing agent during and after application and of the degree of accessibility of the fiber substance to the finishing agent. In some cases, the principles of ionic adsorption have enabled us to define the problems more clearly but there is still a great deal to be learned about the molecular forces acting between the finishing agent and the fiber.

E. I. Valko, E. F. Drew & Co., before Division of Colloid Chemistry, American Chemical Society, San Francisco, March 29, 1949.

DUST COLLECTION

. . . *Electrical and Mechanical*

W. A. *Schmidt*

It has been known for a long time that the rate of precipitation differs widely with different fumes and dusts, that particle size and particle concentration are contributing factors, and that adverse back discharge is largely dependent upon the electrical conductivity of the deposit. It has now been shown that the resistivity of the deposit is an important contributing factor under all conditions. It has also been shown that the resistivity of the deposit is affected by temperature and moisture concentration in the gases. The rate of precipitation obviously determines the size of a precipitator. Consequently, it is desirable that conditions within the precipitator should be so controlled that low resistivity of the deposit is maintained. Another factor which has been frequently overlooked, the erosion factor, can be minimized by proper gas distribution and by electrode configuration.

It has been assumed by many that with mechanical dust collectors, definite efficiencies, dependent upon par-

(Continued)

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A GRINNELL-SAUNDERS DIAPHRAGM VALVE works on a simple principle . . . it pinches tight for positive closure and opens wide for streamlined flow. The working parts of the valve are completely isolated from the fluid . . . no corrosion, no contamination and no leaks. Choice of diaphragm material. Body materials . . . cast iron, malleable iron, bronze, aluminum, stainless steel. Body linings . . . glass, lead, rubber or synthetics.

NO METAL-TO-METAL SEAT . . . The large contact area on which this flexible diaphragm seats gives positive closure even when grit, scale or other solid matter is temporarily trapped.

MINIMUM RESISTANCE TO FLOW . . . Smooth streamlined fluid passage without pockets prevents accumulation of sludge and reduces friction resistance to a minimum.

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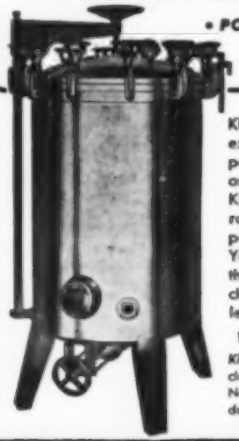

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ticle size distribution, should be obtainable, as this follows logically from the centrifugal force equation. This is not the case. There is always a large overlapping, both in the collection and in the loss, due to turbulence, drag effect, and other factors, which cannot be definitely evaluated.

Walter A. Schmidt, Western Precipitation Corp., before Division of Industrial and Engineering Chemistry, American Chemical Society, San Francisco, March 29, 1949.

INSECTICIDES

. . . *Hazards Minimized*

R. H. Robinson

Fears that widespread use of DDT and other poisonous new insecticides must imperil human health by contaminating food have been minimized by recent research. Studies of the potency of these insecticides have revealed that effective pest control can be achieved by amounts so small they could not possibly be a health hazard.

Moreover, it has been estimated that the amount of all food crops treated with any of the insecticides for the control of one or more pests would be less than 10 percent by weight of the total food consumed daily by the average individual.

There is small chance indeed, therefore, for any insecticide, properly used, to leave residues in amounts that may be dangerous to health.

Most insecticides, old and new, may be regarded as toxic to human beings, but they vary materially in the amounts that may cause physiological complications. Consequently, there is an ever-growing need from the viewpoint of both the farming industry and the consumer to learn at what level trace amounts of different insecticides may be permitted on food without causing health hazards.

R. H. Robinson, Oregon Agricultral Experiment Station, before Division of Agricultural and Food Chemistry, American Chemical Society, San Francisco, March 29, 1949.

PETROLEUM

. . . *Cracker Results*

C. R. Olsen & E. R. Sterba

More and better gasoline from fluid cracking is the goal of refinery process engineers, and the more they know about what will happen when they change the operating conditions in a cracking plant, the faster they can reach highest efficiencies.

At higher temperatures more olefins are made, the "cat cracker" makes a little less gasoline and more gas. The clear gasoline has a higher octane rating, but adding lead to it has less

(*Continued*)

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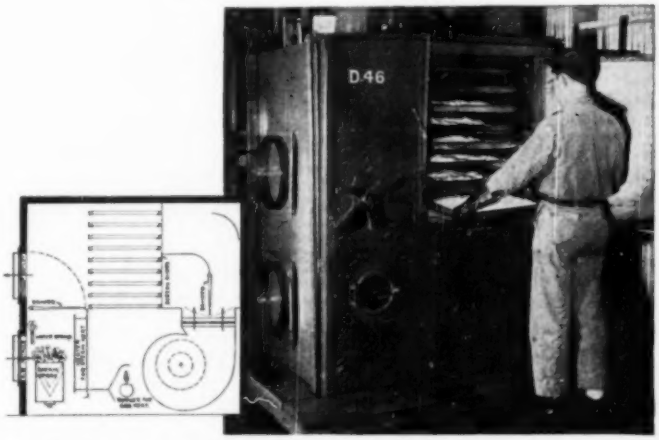
Proctor Variable Circulation Laboratory Dryer Proves Ideally Suited



The complexity of work which passes through the research department of many chemical manufacturers often brings with it, the need for drying under a wide variety of conditions. Then too, drying test work on certain products must often be done right on the premises of the manufacturer. Some products change in physical composition while in transit and cannot be shipped to the dryer manufacturer's research department for accurate study.

To meet the need for drying test work requiring varying conditions or for test work that must be done at the manufacturer's plant—Proctor engineers have designed a variable circulation laboratory dryer. This dryer is being used with marked success by many chemical research departments and in university laboratories.

The dryer, which is customarily furnished for use with eight trays, is designed so that it may be arranged for either cross or through circulation of heated air. When it is set for through circulation—it may further be altered to permit the air to flow up or down through the bed of material on the trays. With this dryer, it is possible to duplicate conditions in continuous systems—making it particularly well suited to pilot plant studies. The heat source may be steam, gas or electricity and the dryer may be furnished with wet or dry bulb temperature controls—or both—depending upon individual requirements.

Frequently when this dryer has been installed and is being used for test work to study the same product, under a wide variety of drying conditions to determine upon a full scale drying system—a Proctor research engineer is on hand to assist with the investigation. This is especially helpful where the product is such that it cannot be transferred to the Proctor laboratory for study.

OTHER PROCTOR LABORATORY DRYING EQUIPMENT...

A small electrically heated laboratory dryer which is well suited to the drying of samples or small quantities of materials that may be loaded on trays or hung on rods or hooks, is also in wide use. This equipment which is simple to connect and easy to operate, offers the answer to the drying needs of many laboratories. Another useful laboratory dryer is one especially designed for skeins and swatches. Textile research laboratories and schools are putting this type of equipment to good use.

For additional information on laboratory drying equipment—write to Proctor engineers today.

Much Proctor drying equipment and textile machinery is covered in full or in part by patents or patents pending.

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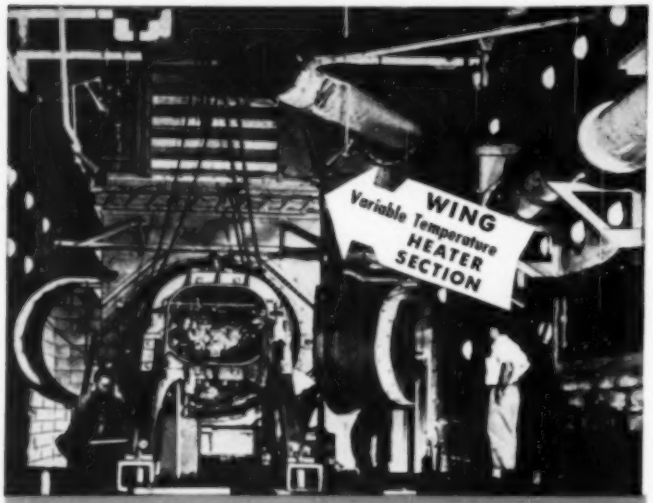
Wing Variable Temperature Heater Section installed in Standard Oil (N. J.) Test Laboratory



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Damage by freezing cannot happen to a Wing Variable Temperature Heater Section even when the entering air is at a very low temperature, because the heating element is always under full steam pressure. Temperature control is achieved automatically or manually by changing damper position, not by reducing steam pressure.

Wing Variable Temperature Heater Sections are used for fresh air supply, for replacing exhausted air, for ventilation plus heating and for drying and process work.

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effect in raising the octane further.

In a large number of tests 45 percent to 70 percent of the gas oil feed stock was converted to other materials.

Tests were run at 800, 900 and 1,000 deg. using a synthetic catalyst. The products from each run were carefully separated into fractions and each fraction was tested.

When operating at constant 60 percent conversion of feed stock, increasing the temperature has the following effects: (1) The yield of dry gas (three-carbon and lighter) increases. (2) The total yield of four-carbon products increases. (3) The gasoline yield (five-carbon and heavier) decreases. (4) The amount of deposit on the catalyst decreases. (5) The proportion of olefins in each part of the yield increases. (6) The proportion of paraffinic constituents increases in the three-carbon and lighter fractions, decreases in the five-carbon and heavier fractions, and remains constant in the four-carbon products. (7) Octane rating of un-leaded gasolines increases—both as determined by the motor method and the research method. (8) The octane sensitivity increases. (9) The effectiveness of tetraethyl lead decreases.

C. R. Olsen and E. R. Sterba, Universal Oil Products Co., before American Institute of Chemical Engineers, Los Angeles, March 8, 1949.

ENGINEERING

. . . *Biochemistry*

Arthur Pollard

In establishing a course of elective subjects in microbiology for chemical engineers, the University of Tennessee was moved by something more than the obvious need to train men for the new fermentation industries such as penicillin and streptomycin. There is a growing appreciation, not to say apprehension, that all is not well between our industrial society and the biosphere which nourishes us and of which we are a part. The alarmist books and articles of the last few months, although perhaps needlessly pessimistic, have at least uncovered the fact that most of us are amazingly ignorant of our place in nature; even though in our daily lives we already feel the pressure of population against resources. Throughout the rest of the world the pressure is grim and unremitting.

It seems certain that the generation of engineers now in school will be concerned with conservation, the elimination of spoilage, and the utilization of waste to a far greater extent than has the passing generation. Fortu-

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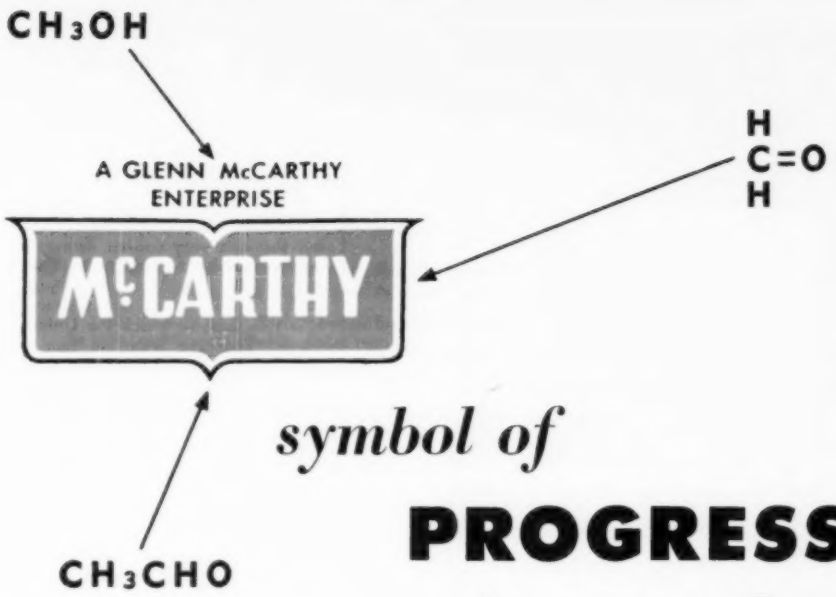

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nately the industrial thought of American industry is far ahead of the rest of us. The house organs of leading chemical companies and the technical press are full of articles on the subject of food preservation, insect control and waste utilization.

Microorganisms cause enormous loss of food stuffs and organic materials but they also may convert damaging waste materials into useful ones. They may, as has been recently demonstrated, create entirely new products. It is this field for which the University of Tennessee hopes to train a few selected students. The modest program which has been under way for more than a year has attracted some outstanding students. It is a satisfaction to them and to the faculty that, upon graduation, there is an immediate demand for their services.

Arthur Pollard, University of Tennessee, before student chapter, American Institute of Chemical Engineers, Knoxville, March 1, 1949.

DISTILLATION

. . . *Azeotropes*

L. Berg, H. C. Carpenter & J. B. Daly

No data are to be found in the literature of chemical engineering on how the charge composition affects the recovery of products from a batch azeotropic distillation. Everyone has taken it for granted that if there is more of one material in the original mixture, more of it will be recovered.

When tests were completed, and results plotted, it was found that more of the more-volatile component of a mix is recovered if more is present in the original batch, but that the same amount of the less-volatile component is recovered, no matter how much of it is present originally. Azeotropic distillation in general has an advantage over ordinarily distillation in giving higher yields than ordinary distillation does.

L. Berg, H. C. Carpenter and J. B. Daly, Montana State College, before American Institute of Chemical Engineers, Los Angeles, March 9, 1949.

INSECTICIDES

. . . *In Bakeries*

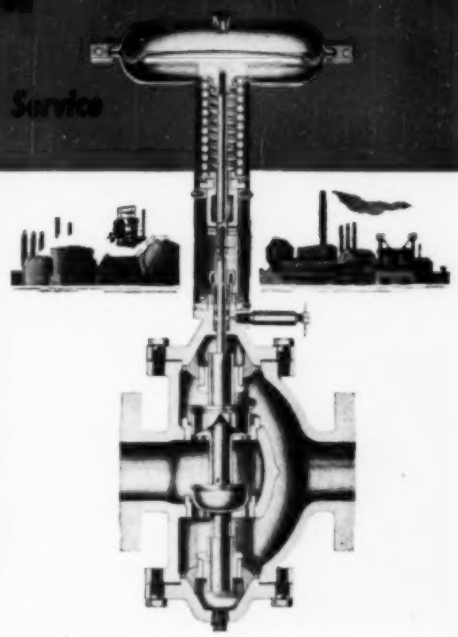
E. L. Holmes

Objections to DDT and chlordane based on the possibility that they might contaminate bakery products, have been proved unfounded. The baking industry needs residual sprays of the DDT and chlordane type to combat successfully the many varieties of pest continually threatening to infest baked goods.

We have no fear that there will be

(Continued)

The Age of Instrumentation Demanded More Accurate Automatic Controls For Steam, Gas, Air, Oil and Liquid Service



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This KONTROL MOTOR Pressure Regulator develops the high sensitivity needed for closer regulation. Extra-long, heat-treated springs, having low stress factors are used together with specially designed diaphragms molded to provide extra contact area. This combination assures uniform operating power throughout the stroke of the valves.

The housing is radical in its effective simplicity. The boltless diaphragm casing is sealed with semi-circular steel clamp rings. Time for disassembly and reassembly to inspect or replace diaphragm is thus reduced to a matter of seconds. Casing and yoke are steel for maximum strength and rigidity. Motors are furnished for DIRECT or REVERSE action without deviation in size or accuracy.

These design advances are typical of the fresh, unfettered thinking Kieley & Mueller urged its engineers to employ in redesigning the entire line of automatic controls to keep pace with the demands of process industries for improved regulator performance under increasingly severe conditions.

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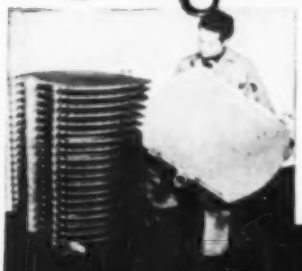

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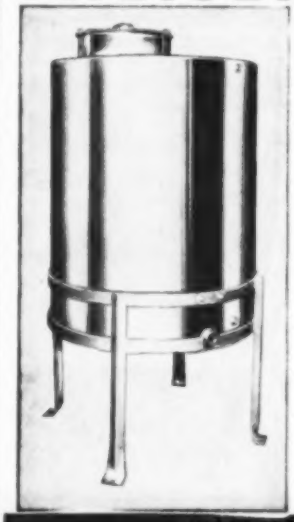

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any contamination of the finished product, for there is no physical necessity of this occurring. Indeed, there is far less danger from contamination here than there has been in the past usage of other poisons such as sodium fluoride powders which were employed for many years without any particular adverse publicity, despite infrequent food poisonings resulting from their use.

When a bakery is kept as clean as possible, Dr. Holmes said, "it is believed that the application of a residual layer of toxic insecticide on those areas on which casual invaders are most likely to travel in seeking harborage will effectively kill the casual invader individual before it has an opportunity to nest. Experience has borne out this theory in a general way, and specific data are now being collected to support it.

Both DDT and chlordane are used, the former in a 5 percent solution and the latter in a 2 percent solution. A colorless, odorless oil solvent is employed. The material is distributed from a pressure type spray tank, fitted with a special nozzle which gives a fan-shaped, non-misting spray. A special valve eliminates dripping. The surface to be treated is sprayed until it glistens with wet film, but there is not enough to run. This leaves about 200 milligrams of DDT or chlordane per square foot, in keeping with the recommendation of the United States Public Health Service for spraying homes and food establishments for malaria control.

Edward L. Holmes, American Institute of Baking, and Lloyd J. Salathe, before Division of Agricultural and Food Chemistry, American Chemical Society, San Francisco, March 29, 1949.

AIR POLLUTION

. . . *Sulphur Dioxide*

Morris Katz

Sulphur dioxide from industrial gases in low concentrations is widely distributed in the atmosphere. In concentrations higher than about 0.40 ppm. it may be toxic to sensitive plants at periods during the growing season when physiological activity is high and the conditions for rapid absorption of this gas by the leaves are at a maximum. However, low concentrations, in the range up to 0.10 to 0.20 ppm., have been demonstrated to be without influence on plant life, in the absence of visible markings. There is no effect in this case after long-continued exposure on rate of growth, yield of crop, photosynthesis, respiration, or daily march of the stomata. The effects may be beneficial if the plants are growing

(Continued)

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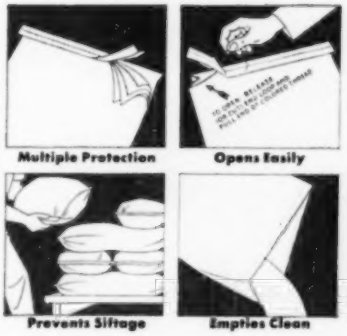

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in a sulphur-deficient soil or nutrient. No basis in fact has been found for the theory of invisible injury.

Morris Kats, Defense Research Chemical Laboratories and National Research Council [Ottawa], before Division of Industrial and Engineering Chemistry, American Chemical Society, San Francisco, March 28, 1949.

MANAGEMENT

. . . *Pilot Plant Experience*

R. B. Semple

Pilot plant work provides excellent opportunities to use important elements of ability and training, and to learn much of company operation. Engineering and chemistry are needed for the pilot plant's transition function of putting the chemistry of the research men in the language of the designing engineer. A project concerning a new industrial chemical, requiring the supply of introductory commercial quantities (often called interim manufacture), touches on many phases of company activity. Sales and sales development are vitally concerned. Production is preparing to take over. Engineering is designing and planning construction. Service departments, such as accounting, purchasing, traffic, and safety, are contributing. Thus an unusual opportunity exists to learn the scope, philosophy, and methods of these important activities. Most factors bearing on the if and how of a project are represented. The pilot plant technologist, however, is not directly concerned with the why of a project, a function of management's development and policy-forming groups. However, as an eventual candidate for this high level activity, the technologist can find no better medium than the pilot plant for equipping himself with vital experience in the realm of "if and how." Obviously, the desirable pilot plant man is a broad type of technical individual, with aptitudes for good personal relations and for common sense judgment.

Robert B. Semple, Monsanto Chemical Co., before Division of Industrial and Engineering Chemistry, American Chemical Society, San Francisco, March 29, 1949.

PATENTS

. . . *National Suicide*

Crosby Field

In civilizations of little individual freedom, inventions can rarely be made, and can be introduced from other lands only by governmental permit, and then not primarily for the benefit of the common man. If made, inventions rarely develop beyond the sketch book. In those most

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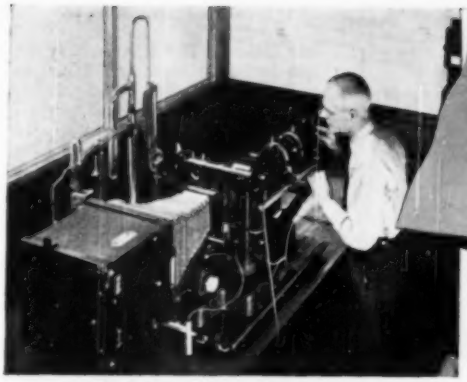

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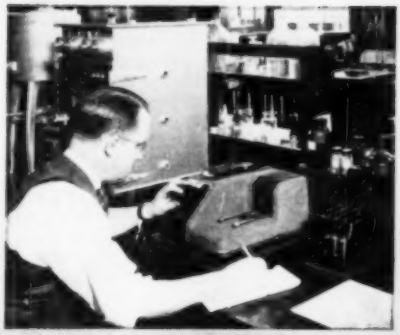

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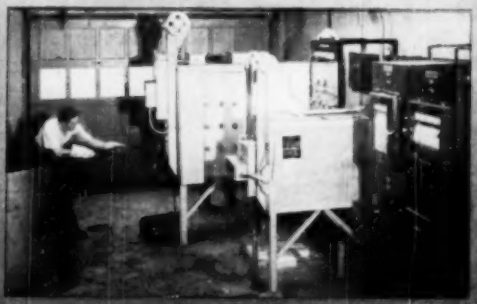
Creep Testing



Heat Treatment Determination

Radiographic Inspection

Hardness Testing

VAPORIZING LIQUID
The all-purpose extinguishers effective on almost every kind of fire. Safe on electrical fires, too! Hand or pressure operation.
CHEMICAL FOAM
2½ gal. size produces about 22 gals. of fast-acting foam. Ideal for flammable liquid hazards. Also 10 gal. and 40 gal. (above) wheeled units, and systems.
CARTRIDGE-OPERATED
Eliminates annual recharging. For fires in wood, paper, textiles. Shoots water or anti-freeze solution. 2½ gal. size.
AIR FOAM
Couple Playpipe to hose line. Every 15 gals. of water and 1 gal. of PYRENE Foam Compound yield 350 gals. of foam! For ordinary combustibles and flammable liquids.
SODA-ACID
Standard protection for ordinary combustibles. Shoots a steady 40 ft. stream. 2½ gal. size. For offices, factories, stores. Also 40 gal. wheeled units.
MANUAL AND AUTOMATIC SYSTEMS and other extinguishers
Pyrene has what it takes
Name any kind of fire hazard— there's a PYRENE to guard it
Every PYRENE* product is precision-made for *sure* protection. When you want new PYRENE extinguishers, you can get them quickly . . . distributors in all leading cities carry them in stock. There are 180 PYRENE service depots throughout the country ready to give you immediate repair service on PYRENE pump-type extinguishers or furnish parts for other types. Depend on PYRENE for all your extinguisher needs. Write for addresses of your local distributor and service depot.
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rare incidents that they do they are very limited in their application. In civilizations of much individual freedom, inventions can be used, but their advent is only occasional and then they are used almost exclusively for the elite. In civilization, which have not only individual freedom but also the means of inducing a perpetual steady flow of invention, the benefits of invention reach practically the entire population. The only means yet discovered for inducing this flow is the limited time protection of a patent system similar to the American. The multitude of separate inventions thus induced soon join to produce a steady stream of mechanical progress which, excepting for short termed monopolistic small tributaries, is entirely in the public domain.

Great as are the material everyday benefits the common man receives from this induced flow of invention, and the freedom of the inventor or his agent to exploit each invention, the greatest is the self-perpetuation of the society permitting and encouraging them. We have seen empires and nations come and go, none had this induced flow of invention. We ourselves have passed through great crises; individual freedom and this induced flow of invention have been of the utmost value in saving us. The American patent system is the only true inducer of the invention flow so far discovered. Its abolition or emasculation, therefore, is not merely a matter of slowing down our material benefits; it is actually a step toward national suicide.

Crosby Field, Fiaklee Corp., before American Patent Law Association, Washington, Feb. 15, 1949.

PETROLEUM

. . . *Sulphur Removal*

Alexis Voorhies, Jr. & W. M. Smith

More high-test gasoline from poor grades of crude oil can be made by a new process which removes sulphur, the bugaboo of petroleum refiners.

Sulphur in gasoline increases fuel consumption, corrodes engine parts and causes knocking. Sulphur can now be largely eliminated from petroleum prior to cracking by the addition of hydrogen gas under relatively low pressure. The entire change, from low-grade crude to high-test gasoline, can be accomplished in a single step.

Although catalytic cracking provides an excellent means of converting most petroleum stocks into the maximum amount of gasoline, other problems still harass the refiner.

The more sulphur there is in the

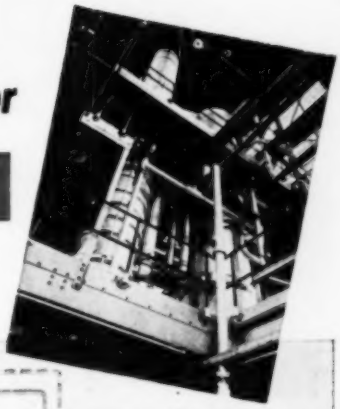
(Continued)

CHEMICO

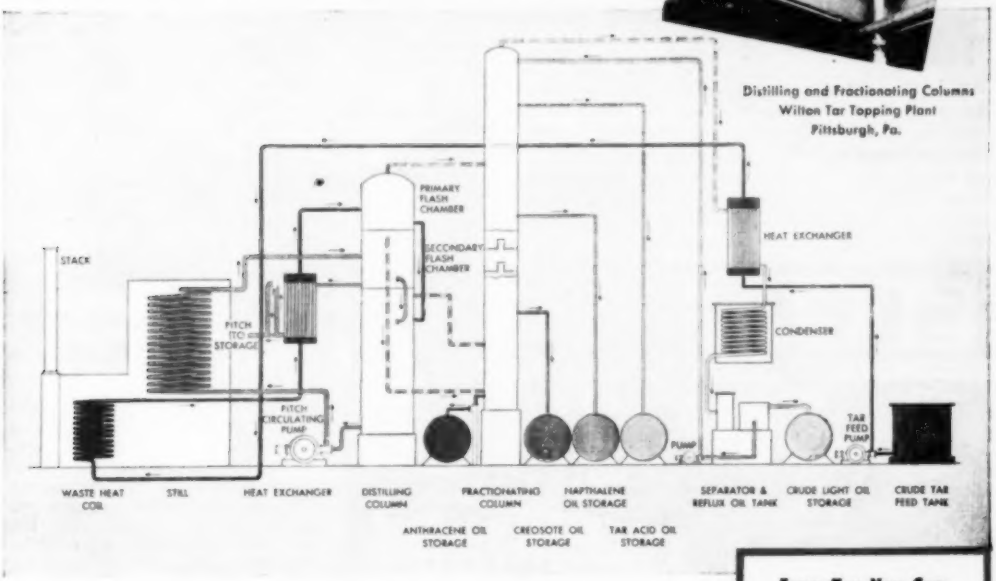
Offers The Wilton Continuous Process For

TAR DISTILLATION

Pitch recirculation reduces coking of pipe still . . . lowers maintenance cost



Distilling and Fractionating Columns
Wilton Tar Topping Plant
Pittsburgh, Pa.



PROCESS

In the Wilton process hot pitch is *continuously* circulated at high speed through the distillation column to the pipe still and back. Tar products of the desired characteristics are removed in continuous streams.

ADVANTAGES

Fewer shutdowns — Turbulence of the pitch in the pipe still prevents coking even when the entry of crude coal tar is stopped. This reduces shutdowns for cleaning and repairs . . . substantially lowers maintenance costs.

Higher yield — Corrosive liquids and light oils are distilled off immediately upon introduction of crude tar to the hot recirculating pitch. This not only insures a high yield of oil products, but also reduces corrosion of the equipment.

Lower fuel costs — Maximum heat exchange occurs between hot finished products and cold feed. No re-distillation of oil products is necessary. Various fuels, including pitch from the same unit, or a combination of fuels can be used.

Greater flexibility — Any product can be varied without affecting the others. Plants can be worked on quarter, half or full load, without detriment to the pipe still.

Less space — Installations for modern-size, coke-oven batteries occupy ⅓ to ½ less space than comparable batch plants.

Automatic controls — Centralized, automatic controls insure constant quality of products as well as lower labor operating costs.

Every Chemico-built plant is backed by 35 years of experience in the design and construction of heavy chemical installations. Consult Chemico for all your heavy chemical plant needs.

From Tar You Can Get These Products

1. Low-boiling acid-oil fraction with high concentration of phenol and cresols.
2. Naphthalene oil fraction containing practically the whole of the naphthalene in the crude tar.
3. Creosote oil fraction which can be made to comply with various specifications for use as wood preservative or for use as benzol-absorbing oil.
4. Higher boiling fractions containing concentrations of chemicals such as anthracene, phenanthrene, carbazole, etc.
5. Pitches, hard or soft, to meet fuel, surfacing, coking, waterproofing, etc. specifications.

DD-181

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These engineering triumphs . . . found only in Zenith Press . . . are available to paper pulp, cannery, corn starch, fish reduction, meat packing, glue, citrus waste drying and many other processes.

For further plant uses, for individual problems or for engineering or additional data, write Jackson & Church Company at Saginaw, Michigan.

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crude petroleum, the tougher is the job of refining the products in order to eliminate sulphur, which is an objectionable impurity in gasoline, kerosene, and fuel oils. In the case of gasoline, sulphur is objectionable both because it tends to cause corrosion in the engine, and also because it causes knocking. The phenomenon of knocking, or pinging, results in poorer engine performance, engine overheating, and fewer miles to the gallon of gasoline consumed.

Low pressure hydrogenation will allow the production of high quality gasolines of satisfactorily low sulphur content in one step from poorer grade crude petroleum oils of high sulphur content, from which low sulphur gasoline cannot be produced by catalytic cracking alone. Furthermore, the new process makes possible the production of still more gasoline from a barrel of crude. Neither of these two important features is unique to low pressure hydrogenation, but on the basis of cost the process appears to be outstanding.

Alexis Voorhies, Jr., and W. M. Smith, Esso Standard Oil Co., before Division of Petroleum Chemistry, American Chemical Society, San Francisco, March 31, 1949.

MARKET DEVELOPMENT
. . . *Agricultural Possibilities*

C. A. Setterstrom

Many new compounds are of value because of their physiological properties—their effects upon living organisms. The life processes are complex chemical syntheses and degradations. As more is learned about these processes, it will be discovered that they can be inhibited or accelerated, initiated or terminated, modified and controlled by the use of efficient new organic and inorganic chemicals. Parathion and DDT, the sulfa drugs, the antimalarials and antihistaminics, 2,4-D, the dithiocarbamat and glyoxalidine fungicides, and triethylene glycol for air purification are only a few of a rapidly growing list.

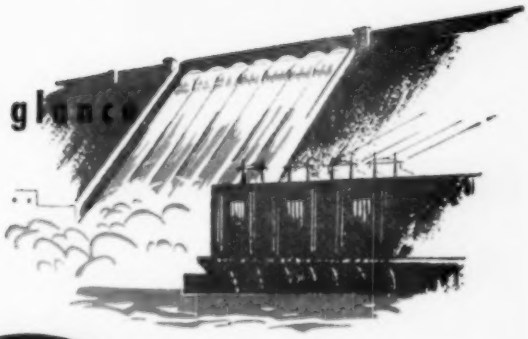
Perhaps the most important potential market for such compounds is the agricultural industry. Chemicals sold to agriculture totaled only $90,000,000 in 1938 and $220,000,000 in 1948, but sales will multiply manyfold during the next decade. The comparatively rapid recent development of new insecticides, fungicides, and herbicides will continue, with growing emphasis on products of low toxicity to man.

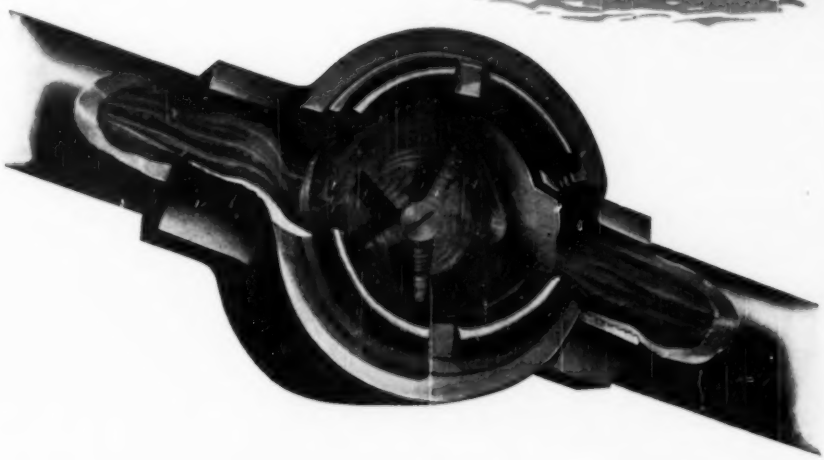
Evaluation of a physiological property usually is difficult and tedious; successful product development requires patience and perseverence. Good judgment is important to avoid

(Continued)

an SK "reason why"

shows flow at a glance





An SK Rotary Flow Indicator . . .
Installed in a pipe line . . .
Permits observation of flow . . .
Shows the condition of fluids . . .
At a glance.

The slightest fluid flow . . .
Causes rotation . . .
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Whose motion can be observed . . .
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wasteful effort on inferior compounds, and to forstall surrender to the difficulties often associated with the best of products. Careful coordination of the skills of the research chemist, the biologist, the engineer, and the salesman also is especially important in this field.

Carl A. Setterstrom, Carbide and Carbon Chemicals Corp., before Division Industrial and Engineering Chemistry, American Chemical Society, San Francisco, March 30, 1949.

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. . . *Versatile Cleansers*

J. B. Niederl & M. E. McGreal

A powerful new series of "multi-cleanser" soap substitutes, which kill germs instantly besides removing dirt, can be used for surgical instruments and household utensils alike.

Some of the new products, known chemically as morpholinium alkyl sulphates, are so potent, that a teaspoonful of detergent is enough to yield a gallon of suds, and at the same time to match the bactericidal strength of a pound of carbolic acid.

J. B. Niederl, New York University, M. E. McGreal, St. John's University, before Philadelphia Section, American Chemical Society, Jan. 20, 1949.

—*End*

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Capacity 2 to 180 GPM
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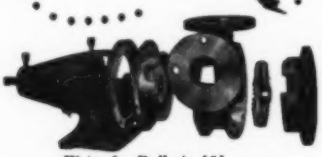

Write for Bulletin 101
ROY E. ROTH COMPANY
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Rock Island, Illinois

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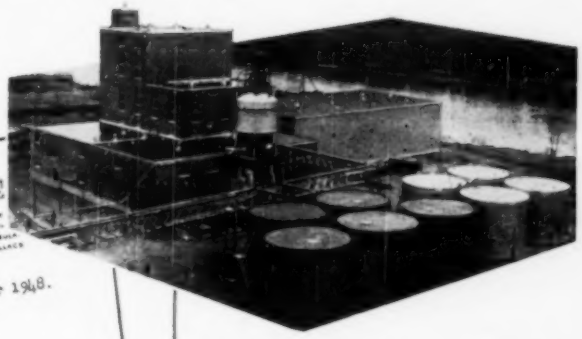
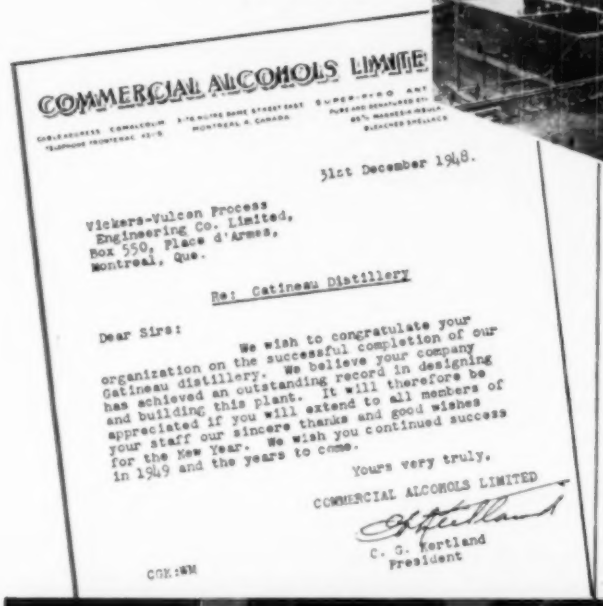




COMMERCIAL ALCOHOLS LIMITED

31st December 1948.

Vickers-Vulcan Process
Engineering Co. Limited,
Box 550, Place d'Armes,
Montreal, Que.

Re: Gatineau Distillery

Dear Sirs:

We wish to congratulate your organization on the successful completion of our Gatineau distillery. We believe your company has achieved an outstanding record in designing and building this plant. It will therefore be appreciated if you will extend to all members of your staff our sincere thanks and good wishes for the New Year. We wish you continued success in 1949 and the years to come.

Yours very truly,

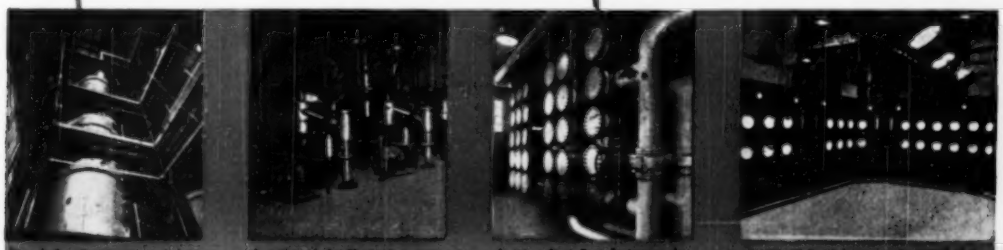
COMMERCIAL ALCOHOLS LIMITED

C. G. Fortland
President

CGK:NM

Under one all-embracing engineering and construction contract covering every phase of process development, equipment and plant design, construction and initial operation . . . Vulcan's Canadian affiliate — Vickers-Vulcan Process Engineering Company, Ltd. announces the completion of the new Commercial Alcohols Ltd. Gatineau Distillery, at Gatineau, Quebec.

This is a typical example of the complete engineering service that VULCAN is offering the chemical process industries throughout the world.



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- ROTATING SEALS OF GRAPHALLOY ARE UNEXCELLED

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FOREIGN LITERATURE ABSTRACTS

Monoxide-Proof Metals for Special Apparatus

So-called carbon monoxide-proof metallic materials, especially steel with more than 13 percent chromium, have been found to be not altogether suitable for practical operation in carbon monoxide hydrogenations under pressures of 300 to 1,000 atm. and temperatures of more than 400 deg., although these materials are apparently not decomposed by carbon monoxide. Twenty different kinds of this type of steel and six iron-free metals were therefore investigated for their reaction to water gas at 1,000 atm. and temperatures of 300-450 deg. in order to determine their practical applicability for building apparatus. The experimental work showed that steels with a minimum chromium content of 13 percent should be used with water gas pressures of 1,000 atm. and temperatures of up to 300 deg. Only steels with a minimum of 17.5 percent chromium, and containing such additions as nickel and silicon, are suitable for the preparation of apparatus and armatures for a temperature of 350 deg. The iron-free metals, such as aluminum, copper and aluminum bronze, behave very well at temperatures of 400-450 deg.

Digest from "Behavior of Carbon Monoxide-proof Materials Toward Water Gas Under Extreme Conditions" by K. H. Ziesecke, *Chemie-Ingenieur-Technik* 21, No. 1/2, p. 15-18, 1949. (Published in Germany.)

Coal Treatment With Pyridine

Almost all the chemical-technical properties of coal are now recognized to be the function of its colloidal structure. Formation of fused semi-coke and solution of coal in organic solvents are colloid-chemical processes; destructive hydrogenation and briquetting are closely related to the colloidal structure of coal. The capacity of lyophilic gels for swelling is the fundamental property which affects most of their other properties. It is therefore only natural that a great deal of attention should be directed toward the determination of the relationship between the capacity of coal to swell and its other properties which may be

(Continued)

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UNLIMITED LIFE
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Low Voltage in the Probe Circuit.

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Two probe rods reach into the tank to the levels where pump-on and pump-off operations are required. Actual contact of the probes with the liquid operates Photoswitch Control which makes and breaks the pump-control circuit.

PHOTOSWITCH Level Controls, effective for all conductive liquids, are available for single-level indication or control, on and off pump control, and boiler feedwater control.

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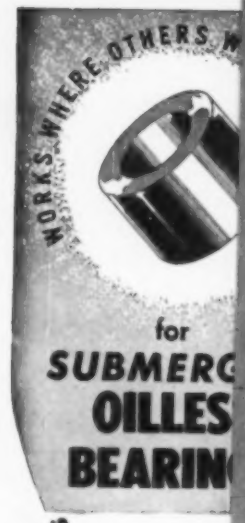

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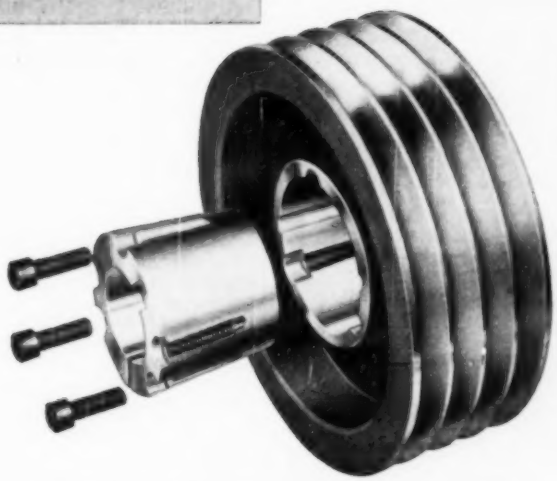

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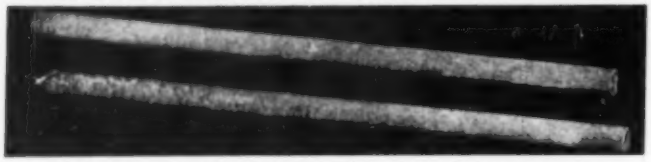

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Pneumix is easier to handle. Standard production unit weighs only 24 pounds and that's a great advantage in batch mixing.

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of practical interest, especially coal's capacity for formation of fused semi-coke in the coking process. Different kinds of coal swell differently in pyridine. "Young," non-clinkering and low-clinkering (long-flame and gas) coals swell a great deal, absorb large quantities of pyridine and rapidly reach a state of saturation. Swelling of these coals is intramicellar; "Riper," clinkering coals (oily and coke) swell much more slowly. It takes them much longer to reach saturation even though they are capable of absorbing comparatively small quantities of pyridine. The first six hours of swelling is intermicellar in character. After six hours pyridine begins to penetrate micelles and the kinetics of this process proceeds according to an equation of the rate of reaction of the second order, as in "young" coals. Still "older" coal (lean) swells very little. The kinetics of swelling can be characterized by two parameters: (1) quantity of pyridine which can be absorbed by the coal (the limit toward which the process is directed) and (2) k = the constant of swelling which is numerically equal to the rate of absorption of the pyridine with the motive power of the process equal to a unit. These parameters change with absolute regularity in proportion to the aging of the coal—assuming lower values the older the coal. It is probable that the difference of properties shown by different coals is due to the difference in their colloidal structure. This structure changes with colloidal aging of the coal.

Digest from "Kinetics of Swelling of Coals in Pyridine" by M. I. Kuznetsov and V. V. Dyibskii, *Zhurnal Prikladnoi Khimii* XX, No. 10, p. 976-986, 1947. (Published in Russia.)

Heat Conductivity of Catalysts

Heat distribution in the catalyst mass of contact apparatus is an essential factor in modern catalytic processes. Optimum temperature change through the catalyst layer is usually attained by heat exchange with fresh gas or some similar medium in the catalyst space. The temperature in the horizontal cross-section of the layer becomes less uniform, however, with increase in the heat exchange through the outer surface of the catalyst. This lack of uniformity reduces the productivity of the catalyst and leads to undesirable side reactions. Heat conductivity of the catalyst layer in the direction normal to the gas current is the basic value which determines the nonuniformity of temperatures in the hori-

(Continued)

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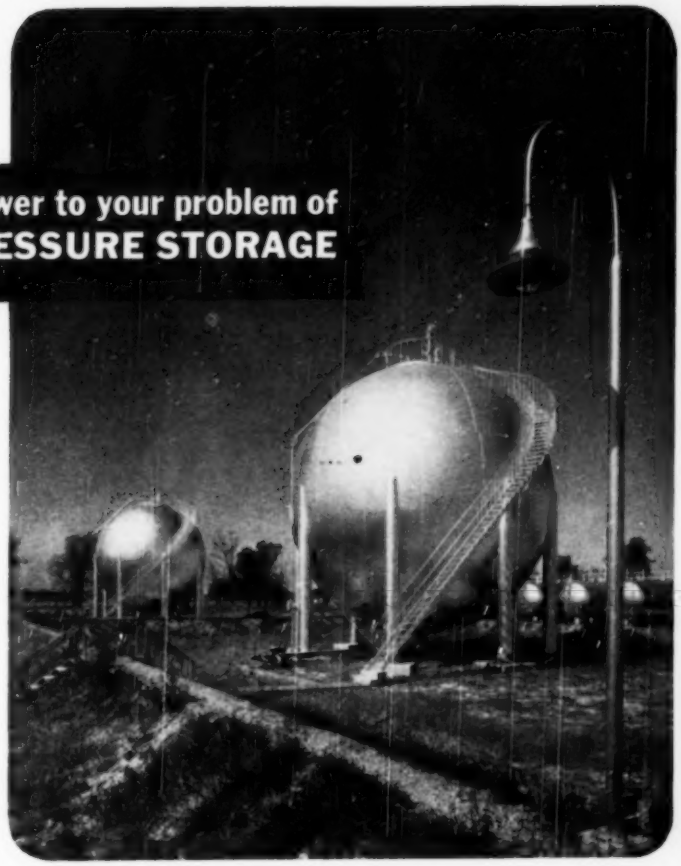

The two clean-cut Hortonspheres shown at the right are installed at a Southern plant. Each sphere is 38 ft. in diam., has a capacity of 5,000 bbls., and operates at a pressure of 100 lbs. per sq. in. These units are typical of the Hortonspheres we build for chemical and process plants for the storage of hydrocarbons, hydrogen gas, anhydrous ammonia, manufactured and natural gases, butane, etc.

Important economies come as natural to the Hortonsphere as its spherical shape. Ideally designed for resisting relatively high internal pressures, the Hortonsphere is widely used by both the chemical and petroleum industries for economical storage of gases and the more volatile liquids.

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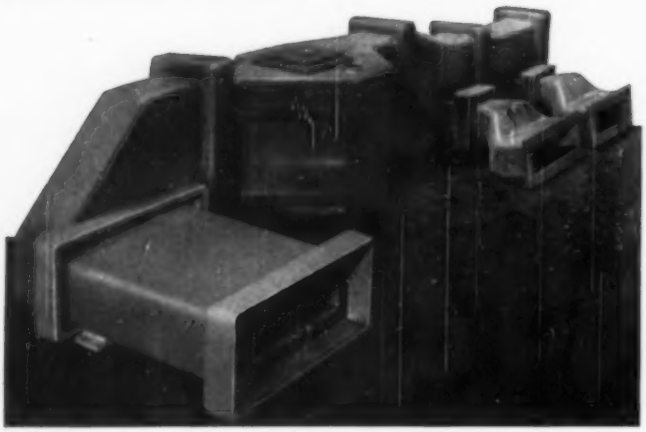

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When completed the KNIGHT-WARE Fume Collector assembly, shown above, consisted of laboratory table fittings, saddle-packed scrubber, fan adapter and connecting ducts. Made of KNIGHT-WARE throughout, it was installed to remove corrosive fumes from the laboratory of a large industrial plant.

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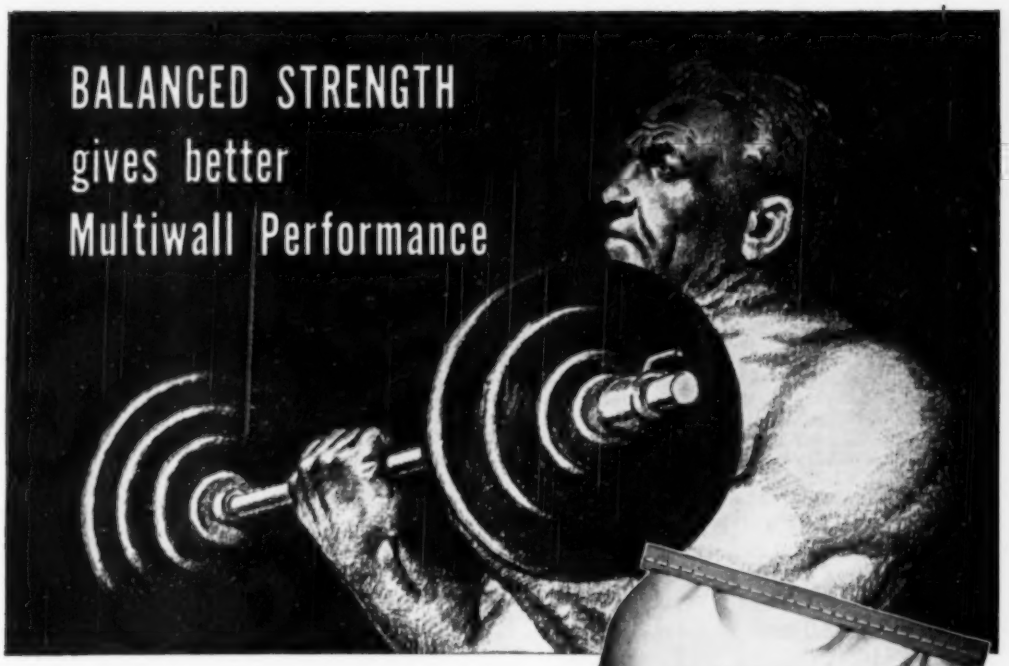
Acid and Alkali-proof Chemical Equipment

zontal cross-section. This value must be known in order to design modern contact apparatus correctly and to select the best construction for the catalyst space. Experimental work was therefore conducted to determine the effective coefficient of the heat conductivity of granular materials in the direction normal to the gas current in order (1) to determine the relationship of the coefficient of heat conductivity in the layer to the rate of the gas current, size and shape of the particles, heat conductivity of the substance of the granules, etc.; (2) to determine the numerical values of the coefficients of heat conductivity which could be utilized in calculating contact apparatus. It was found that the convection component of the effective coefficient of heat conductivity is directly proportional to the linear velocity of the gas and the equivalent diameter of the granule. In the case of bulky granules, the following expression was found for the effective coefficient of diffusion: $D = 575\omega_r d_e$ (in which ω_r is the theoretical linear velocity calculated for the whole cross-section of the charge; d_e is the equivalent diameter); and, correspondingly, for the convection component of heat conductivity: $\lambda_k = 575\omega_r d_e C_p \gamma$ (in which C_p is the specific heat of the gas in large calories; γ is the weight of 1 cu.m. of the gas in kg.). Higher values are obtained for rings and tubes which are distributed haphazardly, due to the additional lateral displacement when gas flows inside of rings placed at a slant. The increase is up to 80 percent for rings with a height equal to the diameter, and still more for tubes with a length exceeding the diameter. The conduction component of the effective coefficient of heat conductivity is equal to 0.25 kg. cal./(M hr.) (deg.) for steel balls in air at 20 deg.; 0.09 kg. cal./(M hr.) (deg.) for porcelain balls; and so low for the other materials investigated that it was within the range of experimental error. The effective coefficients of heat conductivity can be calculated for various catalysts and processes with the help of these formulas. It was found that the convection component is the most important, especially for processes carried out under raised pressures. It was also found that overheating of the central portion of the catalyst as compared with the periphery can be reduced by increasing the linear velocity of the gas and the size of the particles.

Digest from "Effective Coefficient of Heat Conductivity of Contact Masses" by V. O. Bakhurov and O. K. Boreskov, *Zhurnal Prikladnoi Khimii* XX, No. 8, p. 721-738, 1947. (Published in Russia.)

—*End*



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FACTS ON FILTERING

Representative case histories on widely varied clarification problems condensed from field reports of Johns-Manville Filtration Engineers

$127.50 Monthly Profit from Orange Oil Formerly Lost

(reported by J-M Engineer H. G. Martin)

LOS ANGELES DISTRICT: A citrus processor in my territory uses high-speed centrifuges for orange oil recovery. After two weeks' operation, there is an accumulation of about 100 gallons of sludge, which has a high content of orange oil. Settling and decanting this sludge yields 75 gallons of oil. By adding Celite to the remaining 25 gallons of heavy sludge formerly discarded and then pressing it, 5 more gallons of orange oil are recovered. Selling for $1.50 per pound, this means a saving of $130.00 in additional orange oil per month. Deducting $2.50 for the cost of Celite used, the operation shows a monthly net profit of $127.50.

Cutting Oil Recovery Increased 12 Times

(reported by J-M Engineer Carl Dietz)

CLEVELAND DISTRICT: This fabricating concern had recently set up an outfit for the recovery of cutting oil from brass, bronze and steel alloy turnings and cuttings. The outfit consisted of a horizontal plate filter, centrifuge, dirty oil tank, and clean oil tank. Having the usual starting-up troubles, they asked for my help.

I found that they had been attempting to operate the filter by pumping clean oil from the filter into a closed tank. This raised the pressure to an excessive level. After correcting this condition, I filled the filter by gravity before starting the pump. Using 7.5 lbs. of Celite 503 per 300 gallon batch, the entire batch was run through in less than an hour. It was apparent that they could take another 300 gallons through the filter—yet previously they had been unable to obtain a throughput of more than 50 gallons.

Since then, no trouble has been experienced. Customer states that in spite of high steam and air charges, he is able to recover his cutting oil at a cost of 3.5¢ per gallon.

Trouble Traced in a Varnish Plant

(reported by J-M Engineer R. J. Amberg)

DETROIT DISTRICT: Recently, a varnish company complained that their filter was not giving satisfactory performance, so I went to the plant to see if I could locate the difficulty. There I found that the hot varnish flows from an elevated storage tank into a 50-gallon drum where the filter aid is added. This drum supplies the filter. During the filtering run, I noted that the operator would occasionally allow the drum to empty and the pump would then pull air for as long as five minutes—draining the filter, "scouring" the filter element and rendering subsequent filtration almost impossible.

The operator was instructed to keep the varnish level well above the outlet pipe. Then, four 400-lb. drums were filtered at an average rate of 18 gallons per sq. ft. per hour with only 5 lbs. gauge pressure at the end of that period. Since that time, these people have had no recurrence of the difficulty.

Engineering Help Solves Filtration Problem

(reported by J-M Engineer G. F. Huber)

BOSTON DISTRICT: One of my customers was having difficulty due to the filter powder coming through the ceramic filter medium. I checked the operation with their technical director and found that incomplete venting of the air from the filter body during precoating permitted air to remain trapped in the upper part of the filter. This prevented the precoat suspension from filling the filter and depositing an even coat upon the stone. As the filtration was continued, the liquid level in the filter rose and gradually displaced the air but meanwhile, of course, some filter aid passed through the stone.

I suggested complete air venting at the start of the precoating and installing a valve on the outlet side. This change in operation resulted in a decided improvement and, needless to say, the customer was greatly pleased.

Your New Problem may be an old one to the CELITE Engineer

These case histories show not only what Celite Filter Aids can do but also how Johns-Manville Filtration Engineers can help you. Small, simple changes in equipment or technique often lead to big results because J-M Engineers combine scientific knowledge with wide practical experience on many filtration problems.

For additional information, write Johns-Manville, Box 290, New York 16, New York.

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Chemical Engineer's Bookshelf

LESTER B. POPE, Assistant Editor

Caveat Emptor

FUNDAMENTAL ORGANIC CHEMISTRY. By Ed F. Degering and collaborators. University Lithoprinters, Ypsilanti, Mich. 516 pages. $4.50.

Reviewed by C. G. Overberger and William E. Doering

The senior author states in the preface that this book is an attempt to present to the student of organic chemistry the theoretical and practical aspects of the field in a concise, dynamic, interesting and systematic manner. Undoubtedly, a sincere effort has been made to fulfill this purpose.

It is divided into five main divisions: (1) Kaleidoscopic Survey; (2) The Aliphatic Series; (3) The Alicyclic Series; (4) The Aromatic Series; and (5) Heterocyclic Compounds. The first division is further broken down into the headings: Relative Electronegativity; Homologous Series, Structure; A Resume of Structure; Why Reactions Take Place; and Reaction Mechanism.

Some of the conclusions presented in this first division are largely a result of misinterpretation of some fundamental principles and these reviewers question their validity.

Some of the more glaring misconceptions are the following. On page 19 the author presents an explanation of the addition of hydrogen chloride to propylene which is based on initially assigning relative electronegativities to the three carbon atoms. To these reviewers, the explanation is not valid. On page 23, footnote 4, the statement is made that an electronic hybrid is an equilibrium of two or more electronic forms. This is not the correct conception of the resonance principle. Other misinterpretations involve the vapor phase chlorination of propylene, page 32, and the chlorination of methane, page 82. On page 81 it is stated that carbonium ions are comparable to ammonium ions.

The other four divisions do contain a large amount of specific information, but they also suffer because reference is made to division I. On page 383 the mechanism presented for the reaction of benzene with ethylene in the presence of aluminum chloride and small quantities of moisture and hydrogen chloride is non-informative. Since carbonium ions and equilibrium were introduced to the student in division I, an effective mechanism could have been presented without difficulty. On page 387, a rule is presented to predict orientation in aromatic substitution reactions. The value of such empirical rules with our present knowledge of the mechanism of aromatic substitution is questionable.

The authors' explanation of aromatic substitution in terms of relative electronegativity in paragraph 851 is a poor attempt to assign fixed charges to a dynamic system, has been tried before, and in the opinion of these reviewers is not valid.

If the reader omits division I, the book may be useful in reviewing systematically, in the classical tradition, a wide variety of organic reactions. In this respect, it is comparatively free of printing and chemical errors. Likewise, there is ample and useful coverage of industrial processes.

In the opinion of these reviewers, the representation of the electronic characteristics of bonds by animated cartoons ("the girl characters have 'oomph,' are electron attracting, or relatively negative, whereas the boy characters are repulsive, electron repelling or relatively positive") is in very poor taste.

These reviewers are unable to recommend this book for teaching organic chemistry.

RECENT BOOKS RECEIVED

Absorption Spectrophotometry. By G. F. Lothian. Hilger. $7.60.

Biochemical Preparations, Vol. I. By H. E. Carter. Wiley. $2.50.

Colloid Chemistry. 2nd ed. By H. B. Weiser. Wiley. $5.50.

Encyclopedia of Organic Chemistry, Vol. 12B. By F. Radt. Elsevier. $32.

Encyclopedia of World Timbers. By F. H. Titmuss. Philosophical Library. $4.75.

The Essential Oils, Vol. II. By E. Guenther & D. Althausen. Van Nostrand. $10.

Fundamental Processes of Dye Chemistry. By H. E. Fierz-David & L. Blangey. Interscience. $9.50.

Introduction to Chemical Science. 2nd ed. By W. H. Hatcher. Wiley. $4.

Methods of Quantitative Micro-Analysis. By R. F. Milton & W. A. Waters, Arnold. $15.

Radioactive Measurements With Nuclear Emulsions. By H. Yagoda. Wiley. $5.

Surface Active Agents. By A. M. Schwartz & J. W. Perry. Interscience. $10.

Trade-Marks. By H. Bennett. Chemical. $10.

Treatise on Powder Metallurgy, Vol. I. By C. G. Goetzel. Interscience. $15.

Smells

ODORS, PHYSIOLOGY AND CONTROL. By Carey P. McCord and William N. Witheridge. McGraw-Hill Book Co., New York. 405 pages. $6.50.

Reviewed by Edward Sagarin

The need has long been felt for a new technical survey of man's knowledge of smell, its physiological background, its chemical causes, its industrial and legal implications. The work of Bienfang was altogether too light, anecdotal, discursive, to fill this gap, while that of Moncrieff, with its emphasis on the chemistry of odor, left untouched the vast field of its utilization, cancellation, masking, absorption, and adsorption. To this task, the present authors have brought their experience in industrial health and in ventilation engineering, a thoroughness in historical research, and an objectivity in the evaluation of odor systems that is unfortunately rare. Particularly in those parts of the book dealing with engineering (ventilation, odor absorption, etc.) and again in two sections on the legal aspects of odor nuisances (the last chapter and a portion of the bibliography), this reviewer knows of nothing that has been written that is the equal of the present book.

We must take exception to several unscientific passages, which can only be excused on the grounds that they were relatively unimportant to the authors and, therefore, slipped by without proper attention. We refer to several statements concerning racial body odors, statements that are directed against Brazilians, Negroes, and others. To refer to the Negro in this respect as "the best known of the racial offenders," is to trespass on sociopsychological pathways in which the authors do not display their competence. Nowhere is there any sign that McCord and Witheridge are acquainted with the works on this subject of Klineberg, Ashley-Montagu, Archer, et al., nor with the experience and opinion of the great sociologist, Gunnar Myrdal, who concluded, after years of exhaustive study, that he had "not been able to find that Negro Americans have a different odor than white Americans of similar social and economic status," and stated what

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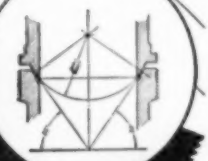

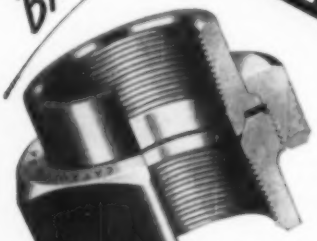

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If you are working with this process, it will pay to standardize on the equipment that's built to do the job most efficiently and economically. Write: Prater Pulverizer Co., 1517 South 55th Court, Chicago 50, Illinois.

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should be obvious to all, though not McCord and Witheridge, that "likes and dislikes in smells of this sort are a matter of personal taste and cultural conditioning."

Many will no doubt admire the authors' bibliography, consuming upward of 100 pages, and containing what appear to be about 3,000 references. We doubt that so huge a bibliography, albeit arranged by subject, is a helpful guide to anyone except a student wishing to do equally thorough research on odor. No indication is to be found as to the value, if such there be, of any given reference; the most worthless mysticism is intermingled with the most significant scientific approach, and if the title is not a hint of value, then no hint is to be found. In spite of its size, the bibliography has very serious omissions, and a small random sampling by this reviewer displayed an alarming number of bibliographical errors of lesser or greater importance.

Despite these serious shortcomings, the McCord-Witheridge book can be recommended as indispensable to all engaged in odor and allied fields.

Abstracts

LITERATURE SEARCH ON DRY CELL TECHNOLOGY. SPECIAL REPORT NO. 27. By Marjorie Bolen and B. H. Weil. State Engineering Experiment Station, Georgia Institute of Technology, Atlanta, Ga. 704 pages. $5.

An indexed, expanded bibliography has been gathered in this volume on (1) dry cell technology in general, (2) manganese ore deposits throughout the world, (3) methods of treating such ores for the preparation of depolarizing compounds. Over 1,500 abstracts of journal articles, books, bulletins and reports and more than 2,300 digests of foreign and domestic patents have been included. An alphabetical subject index, based on the abstracts, covers 60 pages.—*FA*

Safety

UNFALLE BEIM CHEMISCHEN ARBEITEN. By Dr. Ernst and Dr. Alfred Ebert. Rascher Verlag, Zurich. $21.

Reviewed by H. H. Fawcett

This book is the second edition of a study of accidents involving chemicals, written for students, teachers, industrial chemists and supervisors. It is unique in that no book even roughly comparable exists in the English language, in spite of the real need for

(Continued)

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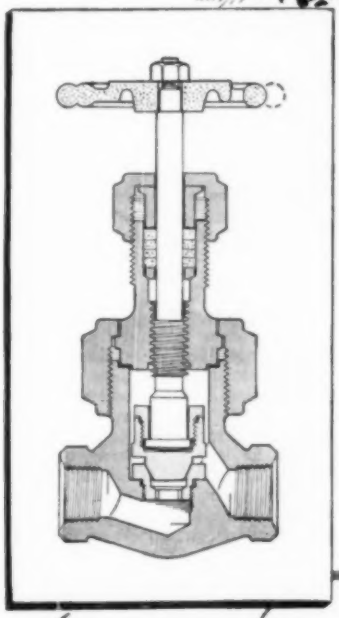

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A. First and foremost is the degree of resistance to clogging when the material has high moisture content. Other differences involve: drying costs, capacity, power consumption, range of reduction, etc. All are important in terms of greater production at less cost.

Q. What single difficulty is the one most often encountered in crushing operations?

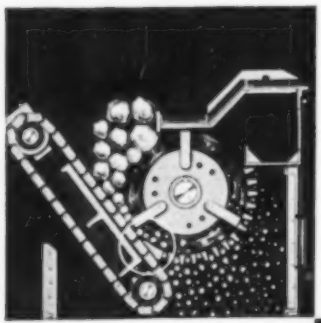
A. "Traffic jams" frequently result through inability of the average hammermill of conventional design to resist clogging in the handling of wet, clayey, sticky material.

Q. Has this difficulty been successfully overcome?

A. Yes... by the development on the part of Dixie engineers of a vastly improved crushing principle known as the Dixie Continuously Moving Breaker Plate.

Q. Is the Dixie Continuously Moving Breaker Plate an exclusive Dixie feature?

A. Yes... covered by U. S. Patents Granted and Pending.



Right! The Dixie Non-clog Continuously Moving Breaker Plate is the distinguishing characteristic of the famous Dixie Hammermill. Its time and money-saving features have practically revolutionized the reduction of raw materials in hundreds of installations all over the world. This singular record of accomplishment, proved in actual case histories, is your positive assurance that you *can do it better with a Dixie.*

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such information in an available form. Two lists, "Industrial Poisons" and "Warning List" issued by the Swiss Cooperation for Chemical Industries, are included. Using the index, containing over 2,500 entries, it is easy to locate the many compounds included, which are discussed from safety, fire, explosion, and toxic standpoints. Of especial interest are the 500 specific accidents involving chemicals, which are completely documented by references. Only a few American references are given—not surprising in view of the extreme reluctance of Americans to add "accidents" to the literature except in very recent times.

Wide use of this book (which even in the German had a very limited circulation) would be a real contribution to safety in chemical operations.

Comprehensive

SCIENTIFIC FOUNDATIONS OF VACUUM TECHNIQUE. By Saul Dushman. John Wiley & Sons, New York. 882 pages. $15.

Reviewed by Benjamin Miller

This is a comprehensive collection of ideas basic to high-vacuum technique, gathered from various fields of science, with references to all the pertinent books and papers and liberal quotations from many. But only one section of less than three pages called "Design of High-Vacuum System" attempts to show how these ideas may be applied. There is some application information in the two chapters on pumps and the chapter on manometers for low gas pressures, but it is incidental; the emphasis is on the basic theory, design and construction of these components, not on their use. This is not the book to introduce chemical engineers to the high-vacuum field, but those working in it and faced with new problems may find help here.

The discussion of mercury-vapor pumps and of vapor pumps using organic fluids is outstanding; it would be even better if Dr. Dushman had included his own views on the relative importance of diffusion, condensation and jet action in vapor-pump operation. The treatment of steam-jet ejectors will seem unusual to chemical engineers. More on the high-speed molecular pump would have been welcome, particularly some explanation for its neglect in this country, while the catalog material on rotary oil pumps could well have been left out.

The section "General Remarks on Gauges" has an excellent discussion of the advantages and disadvantages of

(Continued)

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each type; comparative and order-of-magnitude measurements can be made in several ways, but no method yet described leads to an accurate absolute value of a low pressure. There might well have been included further discussion of the fact that when there is flow the pressure reading is extremely sensitive to the placement of the plane of the gage mouth with respect to the flow direction; the fact is mentioned in the section "Determination of Speed of Pump" but its full significance is not brought out.

The chapters on sorption of gases and vapors by solids; activated charcoal, silicates (including glass), and cellulose; gases and metals; vapor pressures and rates of evaporation; and dissociation of oxides, hydrides, and nitrides, and oxidation rates make up about half the book. They contain much of interest to chemical engineers aside from vacuum technique, some of which is not usually considered in physical chemistry texts. The chapter on chemical and electrical clean-up of gases is important chiefly in connection with sealed-off devices such as electron tubes, but the discussion of getters has much chemical interest.

The chapters on kinetic theory of gases and flow of gases through tubes and orifices is not up to the high standard of the rest of the book. Some of the kinetic theory topics discussed, such as "Determination of Avogadro Constant from Distribution of Particles in Brownian Motion," have no obvious connection with vacuum technique. On the other hand, the general problem of the interaction between molecules and surfaces is involved in many low-pressure problems, and warrants detailed integral treatment, but is only mentioned in passing. Much space is given to the distribution of molecular speeds, though the Maxwell-Boltzmann distribution equations are given without mention of the assumptions on which they are based. The distribution of molecular directions is not even mentioned; instead it is considered that the molecules in a gas at rest are moving in the six directions corresponding to six faces of a cube, which leads to the incorrect conclusion that $nv/6$ molecules will reach unit area in unit time (n = number of molecules per unit volume, v = average molecular speed). The correct relation ($nv/4$ molecules reach unit area in unit time) is given in another place, but without derivation, the discrepancy is not explained.

Space limitation forbids detailed review of the chapter on flow through tubes and orifices. Knudsen's equa-

(Continued)

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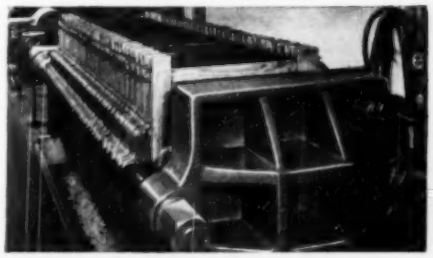

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tions are accepted, despite the experimental results in the "very significant" paper by Brown, Di Nardo, Cheng, and Sherwood to which attention is called. The outmoded concept of the "resistance to flow" of an orifice (which of course offers none) is retained, though two of the errors it has led to are mentioned.

There is an important mistake in a note on turbulent flow. After correctly showing that critical velocity will exist in a cylindrical conduit of length 1 cm. and radius 1 cm. through which air is flowing at 25°C. from the atmosphere to a perfect vacuum if $l/a^3 = 2.2 \times 10^6$, Dr. Dushman states that l must be greater than $2.2 \times 10^6\ a^3$ if the flow is to be *turbulent*. Since it is unlikely that conduits so long relative to their radii will be used, he concludes that turbulent flow is extremely improbable, and never mentions it again. The fact is that l must be greater than $2.2 \times 10^6\ a^3$ for the flow to be viscous under the conditions mentioned, so that turbulent flow is to be expected until the pressure has been reduced to one millibar, and through a short pipe of large diameter a container may be exhausted to 10 microbars without getting viscous flow.

For Practicing Chemists

TECHNIQUE OF ORGANIC CHEMISTRY. VOL. II. Edited by Arnold Weissberger. Interscience Publishers, Inc., New York. 219 pages. $5.

Reviewed by Frederick C. Nachod

Chemists are familiar with the first volume of the series, "Physical Methods of Organic Chemistry," so ably edited by Dr. Weissberger since its appearance in 1945-1946. The present text comprises the following three chapters: "Catalytic Reactions" by V. I. Komarewsky and C. H. Riez of Illinois Institute of Technology and Institute of Gas Technology; "Photochemical Reactions" by W. A. Noyes, Jr., and V. Boekelheide, University of Rochester; and "Electrolytic Reactions" by Sherlock Swann, Jr., University of Illinois.

The same clarity and excellence which prevail in the first book of this series is maintained by the present contributors, all recognized authorities in their fields. Again, emphasis is placed upon the experimental approach and not on underlying theories. One may look upon this series as a much needed addition, amplification, and rejuvenation, of some of the portions of Houben-Weyl's time-honored but dated treatise. Readers will especially welcome Dr. Swann's chapter on elec-

(Continued)

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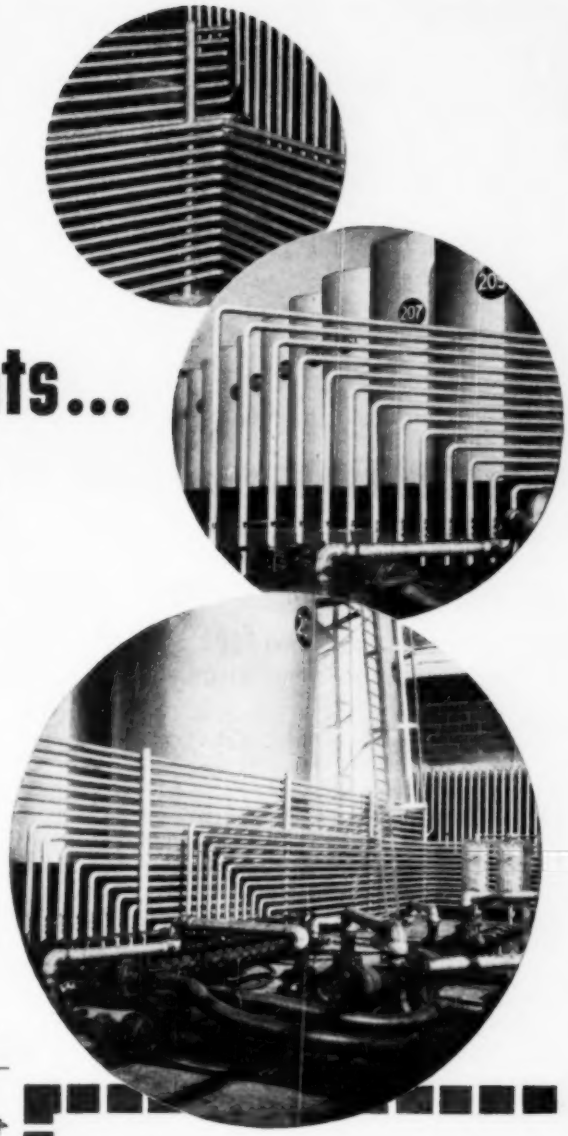

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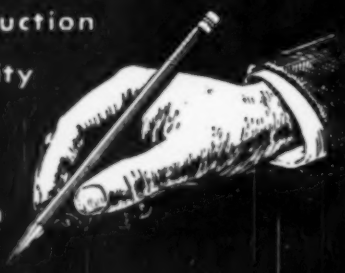

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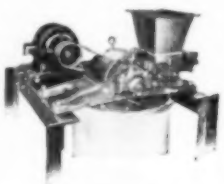

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trolytic reactions as it is not only a streamlined presentation and review but provides many excellent references of the original literature.

This book can be warmly recommended for the practicing chemist be he either in industry or in the academic field.

Chemistry for Laymen

AN INTRODUCTION TO CHEMICAL SCIENCE. SECOND EDITION. By William H. Hatcher. John Wiley & Sons, New York. 449 pages. $4.

True to its title, this text "introduces" the science of chemistry to its intended reader, the non-science student. Opening with a brief historical roundup, it goes on to deal with phenomena and materials most apt to be met in everyday life. The three states of matter, water and its constituents, and the atmosphere are the topics of the first few chapters. Gradually it moves into more technical subjects. Throughout, the author concentrates on principles. Basic facts are thoroughly explained by descriptions and illustrations but technical details are omitted. The four sections of the book discuss inorganic, organic, food and industrial chemistry.—*FA*

Recent Books & Pamphlets

Fluorspar and Fluorine Chemicals. Part I—Economic Aspects of the Fluorspar Industry by N. T. Hamrick and W. H. Voskuil; Part II—Fluorine Chemicals in Industry by G. C. Finger and F. H. Reed. Published by the University of Illinois, Urbana, Ill. 70 pages.

Coding of Thermocouple Wire and Extension Wire. Tentative Recommended Practice, RP1.1 published by the Instrument Society of America, Pittsburgh, Pa. 4 pages. $1. Recommends symbols, in table form, for iron-constantan (Types J and Y); chromel-alumel; platinum-10 percent rhodium-platinum; platinum-13 percent rhodium-platinum; copper-constantan.

Physico-Chemical Investigations on the Treatment of Rock Phosphate With Nitric Acid. By M. H. R. J. Plusje. Published by Netherlands State-Mines, Geleen, The Netherlands. 128 pages plus four fold-out pages of charts. Deals with both theoretical and practical aspects of the subject.

Subsurface Sewage Disposal. By John E. Kiker, Jr. Bulletin No. 23, published by Florida Engineering and Industrial Experiment Station, Gainesville, Fla. 72 pages. $1. Describes subsurface sewage disposal facilities that will just meet the needs under the conditions to be encountered in Florida.

Diffusion Flames. By Kurt Wohl, Carl Gazley, Jr., and Numer M. Kapp. Bulletin No. 1 published by Engineering Experiment Station, University of Delaware, Newark, Del. 35 pages. 75 cents. Report on the quantitative study of the size of flames. Includes an appendix of tables and numerous illustrations.

Bibliography on X-Ray Stress Analysis, With Subject Index. By Herbert R. Isenburger. Published by St. John X-Ray Laboratory, Califon, N. J. 17 pages. $3.

A Philosophy for Conservation. By Edward Steidle. Circular No. 33, published by School of Mineral Industries, Pennsylvania State College, State College, Pa. 51 pages. Gratis. Discusses the progress which has been made in conservation and the needs which still exist.

—*End*

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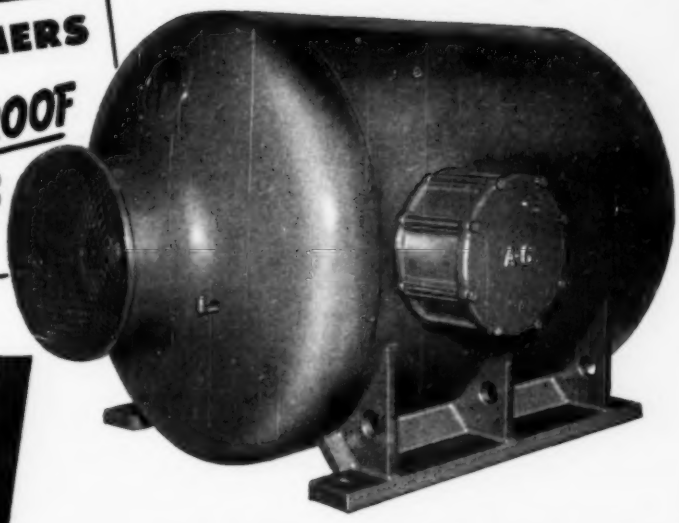

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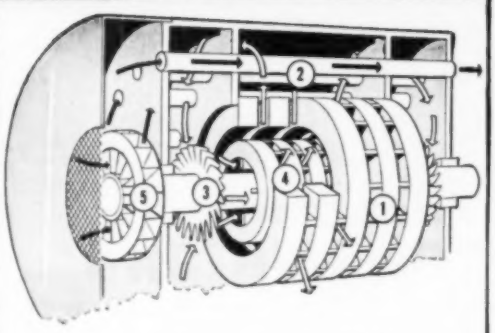

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GOVERNMENT PUBLICATIONS

The following recently issued documents are available at prices indicated from the Superintendent of Documents, Government Printing Office, Washington 25, D. C. In ordering any publications noted in this list always give complete title and the issuing office. Remittance should be made by postal money order, coupons, or check. Do not send postage stamps. All publications are in paper cover unless otherwise specified. When no price is indicated, the pamphlet is free and should be ordered from the bureau responsible for its issue.

Charts of Compressibility Factors and Charts Showing Quantities Delivered by Commercial Cylinders for Hydrogen, Nitrogen, and Oxygen. National Bureau of Standards Miscellaneous Publication M191, Issued November 17, 1948. Price 25 cents.

List of Commercial Standards, Revised to January 1, 1949. National Bureau of Standards, Letter Circular LC931 (Supersedes LC911). Mimeographed.

Simplified Practice Recommendations, Alphabetical List Revised to January 1, 1949. National Bureau of Standards, Letter Circular LC 932 (Supersedes LC 913). Mimeographed.

Definition of pH, and Standards for pH Measurements. National Bureau of Standards, Letter Circular LC 933, November 22, 1948. Mimeographed.

Light-Sensitive Paper No. 1554: Directions for Use In Testing Textiles for Colorfastness to Light: National Bureau of Standards, Letter Circular LC 934 (Supersedes LC 906), January 13, 1949. Mimeographed.

Sources of Bauxite in Asia. By J. F. Harrington. Bureau of Mines, Mineral Trade Notes, Special Supplement No. 27 (to Vol. 26, No. 6) June 1948. Mimeographed.

Protection Against Mine Gases. By J. J. Forbes and G. W. Grove. Bureau of Mines, Miners' Circular 35, Revised 1948. Price 20 cents. Describes various barricades, gas masks, self-rescue respirators, oxygen breathing apparatus, and treatment for gas poisoning or asphyxiation.

Safety and Performance Characteristics of Liquid-Oxygen Explosives. By W. E. Tournay, F. M. Bower and F. W. Brown. Bureau of Mines, Bulletin 472. Price 30 cents.

Hazards of Black Blasting Powder in Underground Coal Mining. By D. Harrington and R. G. Warncke. Bureau of Mines, Information Circular I. C. 7402. Mimeographed.

German Low-Temperature Coal-Tar Industry. By E. O. Rhodes. Bureau of Mines, Information Circular I. C. 7400. Mimeographed. One of a series written by members of the Solid Fuels Mission in Germany; a companion to Information Circular I. C. 7409, "German High-Temperature Coal-Tar Industry."

Synthetic Liquid Fuels Abstracts, Items 127-268. By J. L. Wiley and H. C. Anderson. Bureau of Mines, Vol. 2, No. 2 (new series), March 1949. Mimeographed.

Gaseous Reduction Methods for the Production of Sponge Iron. By E. P. Barrett. Bureau of Mines, Report of Investigations R. I. 4402. Mimeographed. A general picture of the methods, proposed or tried

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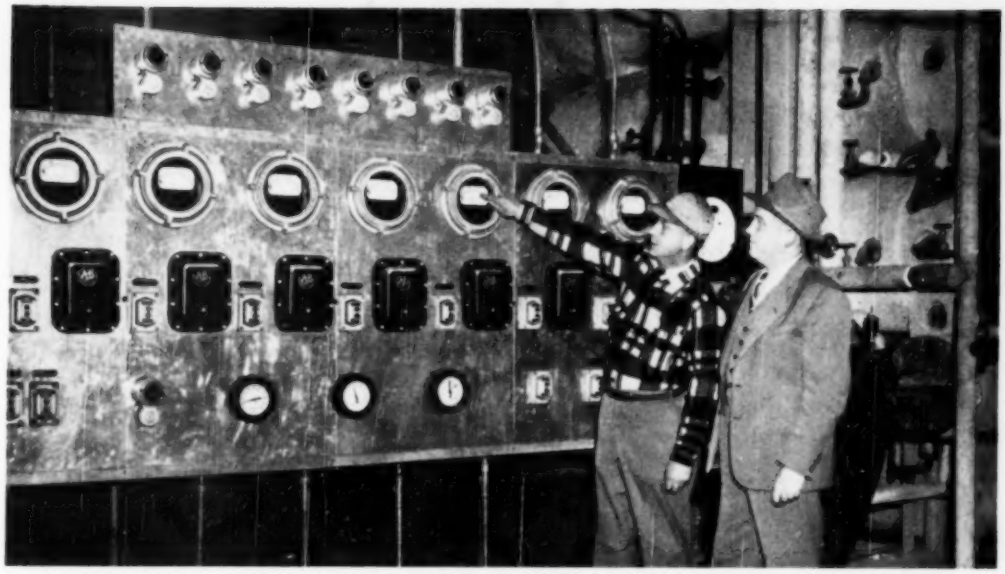

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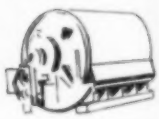

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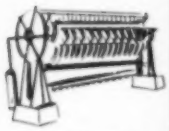

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Nylon Filter Cloth can be supplied in several weaves and weights and in rolls or made-up filter element covers with all Nylon-Thread sewing.

Literature and pilot test samples of FM Nylon Filter Cloth are available on request.

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GOVT. PUBS., *cont. . .*

within the past 100 years, for producing sponge iron by treating hot ore with heated reducing gases.

Bleaching Wood. By Leslie E. Downs. Forest Products Laboratory, No. R1705. Available only from Forest Products Laboratory, Madison 5, Wis. Describes methods and types of bleaching wood with chemicals.

Laboratory Studies of the Gravitational Drainage of Oil from Unconsolidated Sands. By R. V. Higgins and G. B. Shea. Bureau of Mines, Report of Investigations R. I. 4391. Mimeographed.

Investigation of the Sheep Creek Iron Deposits, Meagher County, Mont. By Glenn C. Reed. Bureau of Mines Report of Investigations R. I. 4400. Mimeographed.

Investigation of Broughton and Ring Magnetite Deposits, Essex County, N. Y. By Robert S. Sanford and L. H. Stone. Bureau of Mines, Report of Investigations R. I. 4404. Mimeographed.

Investigation of Limestone Deposits Near Arlington, Snohomish County, Wash. By Constantine C. Popoff. Bureau of Mines Report of Investigations R. I. 4393. Mimeographed.

Investigation of Black Mountain Beryl Deposit, Oxford County, Maine. By E. E. Maillot, M. F. Boos, and M. Mosier. Bureau of Mines, Report of Investigations R. I. 4412. Mimeographed.

Investigation of Muir Inlet or Nunatak Molybdenum Deposits, Glacier Bay, Southeastern Alaska. By R. S. Sanford, G. A. Apell, and F. A. Rutledge. Bureau of Mines, Report of Investigations R. I. 4421. Mimeographed.

Investigation of Chester Limonite Deposit, Berkshire County, Mass. By R. J. Burgess and R. S. Sanford. Bureau of Mines, Report of Investigations R. I. 4423. Mimeographed.

Investigation of Certain High-Alumina Clays of Central Pennsylvania. By R. S. Sanford. Bureau of Mines, Report of Investigations R. I. 4427. Mimeographed.

Investigation of Sweetsprings Manganese Deposits, Monroe County, W. Va., and Craig County, Va. By H. V. Ewoldt and R. S. Sanford. Bureau of Mines, Report of Investigations R. I. 4433. Mimeographed.

Investigation of Douglas Fluorite Property, Pope County, Ill. By O. M. Bishop and A. B. Needham. Bureau of Mines, Report of Investigations R. I. 4434. Mimeographed.

Petroleum Engineering Study of the West Red River Field, Tillman County, Okla. By H. V. Hill, et al. Bureau of Mines, Report of Investigations R. I. 4450. Mimeographed.

A Tentative Titanium-Nickel Diagram. By J. R. Hayes, et al. Bureau of Mines, Report of Investigations R. I. 4463. Mimeographed. A progress report on titanium-nickel alloy studies.

Sheath Working of Metal Powders. By J. R. Long and E. T. Hayes. Bureau of Mines, Report of Investigations R. I. 4464. Mimeographed. Deals primarily with ductile titanium, but applicable to many other metal powders and mixtures.

Imports of Coal-Tar Products 1948. United States Tariff Commission, March 1949. Mimeographed. United States imports for consumption of intermediates, dyes, medicinals, flavor and perfume materials, and other finished coal-tar products entered in 1948 under paragraphs 27 and 28 of the Tariff Act of 1930.

Copper Naphthenate Wood-Preservative. National Bureau of Standards, Commercial Standard CS152-48. Price 5 cents. A recorded voluntary standard of the trade.

Nation-Wide Results with Fungicides in 1948—Fourth Annual Report. Supplement 181 (March 15, 1949) to the Plant Disease Reporter, issued by Bureau of Plant Industry, U. S. Department of Agriculture, Beltsville, Md. Mimeographed.

Fungicidal and Phytotoxic Properties of 506 Synthetic Organic Compounds. Supplement 182 (March 30, 1949) to the Plant Disease Reporter, issued by Bureau of Plant Industry, U. S. Department of Agriculture, Beltsville, Md. Mimeographed.

—*End*

All-Metal GYRATORY SIFTER

HAS WIDE CHEMICAL INDUSTRY APPLICATION

NEW AND DIFFERENT is this A-C gyratory sifter for the chemical industry. It's designed after the Low-Head *standard* gyratory sifter — used by food and chemical processors all over the country. But *this* sifter is new and different because it is made entirely of *metal!*

Numerous materials — ranging from pure chemical products (such as barium nitrate) to impure metallurgical products (such as zinc concentrate) — can be efficiently handled by this sifter. *High-temperature* materials can be sifted since this machine has *no* wooden parts. And cleaning is a simple matter. The entire sifter can be easily and safely *washed*.

The Low-Head all-metal gyratory sifter is a compact, high-speed, high-capacity unit holding four to seven sieves. Made of steel and magnesium, it is a strong, lightweight machine. Sieve screens can be silk or metal, with a variety of fine, medium and coarse meshes to choose from.

This new all-metal gyratory sifter is available *now*. Send handy coupon for full details.

Low-Head is an Allis-Chalmers trademark.

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Chemical Milling and Processing Equipment

ALLIS-CHALMERS, 1147A SO. 70 ST[A 2620] MILWAUKEE, WIS.

☐ Please send handy pocket with information on new All-Metal sifter and standard sifter bulletin 06B6124A.

☐ Would like personal visit from A-C representative with details of new sifter.

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All Layne Well Water Systems are equipped with the famous high efficiency Layne Vertical Turbine Pumps. These pumps are designed and manufactured exclusively in Layne's own plant where every detail of their construction and assembling is under the supervision of engineers.

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MANUFACTURERS' LATEST PUBLICATIONS

Publications listed here are available from the manufacturers themselves, without cost unless a price is specifically mentioned. To limit the circulation of their literature to responsible engineers, production men and industrial executives, manufacturers usually specify that requests be made on business letterheads.

Electric Hoists. *Wright Hoist Division, American Chain & Cable Co., York, Pa.*—8-page folder No. DH-65 describes the line of electric hoists produced by this company. Specifications are given for these hoists, which range in capacity from ½ to 10 tons.

Air Compressors. *Worthington Pump & Machinery Corp., Publications Dept., Harrison, N. J.*—4-page folder is a selection chart for use in determining the proper size of water-cooled air compressor. Knowing the quantity and pressure of air required, the chart gives the proper compressor bore and stroke for the application.

Materials Handling. *Abell-Howe Co., 53 West Jackson Blvd., Chicago 4, Ill.*—12-page catalog describes the various types of overhead handling equipment produced by this company. Included are cranes, jibs, monorails, and various accessory equipment.

Dial Scales. *Howe Scale Co., Rutland, Vt.*—8-page Bulletin No. 666 describes the line of dial scales produced by this company. Specifications and sizes are given for these scales which have capacities as high as 300,000 lb.

Pumps. *International Nickel Co., 67 Wall St., New York 5, N. Y.*—8-page booklet, "How to Get Longer Service From Your Pump," discusses the selection of materials for pump construction. Factors covered include corrosion, corrosion-fatigue, erosion and wear.

Fans. *Chelsea Fan & Blower Co., 1206 Grove St., Irvington, N. J.*—Two catalogs, Nos. 863 and 864, describe the line of fans for residential and commercial uses produced by this company. These fans cover a range of output from 1,000 to 30,000 cfm. Specifications and output are shown.

Materials Handling. *Crescent Truck Co., Lebanon, Pa.*—4-page bulletin describes the various types of fork trucks, lift trucks, and tractors produced by this company. Capacities of these trucks range from 1,000 to 10,000 lb.

Protective Coatings. *Witco Chemical Co., 75 East Wacker Drive, Chicago 1, Ill.*—40-page booklet describes the various asphaltic products made by this company, and lists their properties and uses. Some of the items covered include automotive undercoating, sound deadeners, sealers, and rust preventatives.

Annunciators. *Auth Electric Co., 34-20 45th St., Long Island City, N. Y.*—8-page Bulletin No. 120 describes the remote indicators produced by this company for indicating trouble at any location in a plant. The various types of annunciators produced are shown and specifications are given.

Industrial Locomotives. *Apparatus Dept., General Electric Co., Schenectady 5, N. Y.*—A group of new bulletins describes the various types of diesel-electric locomotives produced by this company for industrial switching. Booklet No. GEA-5183 describes the advantages of using these types of locomotives, Bulletin GEA-3756A describes the standard 25-ton locomotive, Bulletin No. GEA-3598B describes the 65-ton unit.

(Continued)

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Assure Improved Plant Methods on

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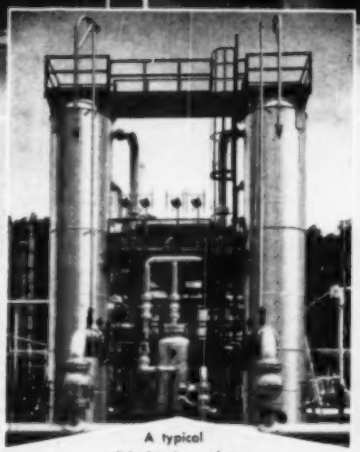
Glycol dehydration plant processing 33 million scf of gas per day with direct-fired reboilers and gas exchanger cooling.



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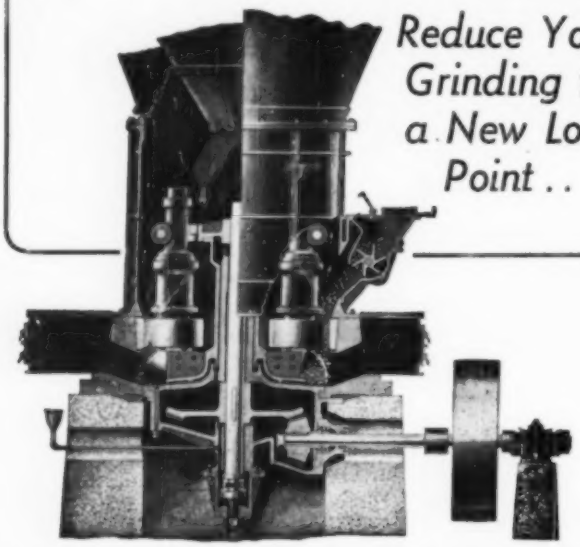

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WILLIAMS ROLLER MILL with AIR SEPARATION

• Greater grinding economy with lowest horsepower per ton of material ground. Positive control of fineness, unusually accurate air separation with no oversize. Instant changeability from a fineness of 70% thru 100 mesh to 99.9% thru 325 mesh. Very high output on unusually fine products. Drying and grinding in one operation. Hundreds of successful installations in the Chemical field attest to their dependability.

Williams Mechanical Air Separator

Designed to handle material that has already been ground or to take the fines out of any dry material that it is desirable to classify. Usually operates in closed circuit with a pulverizer and may be used in this way with almost any type mill. The range of fineness obtainable is approximately from 30 mesh to 325 mesh. Built in nine standard sizes from 2½ ft. to 18 ft.

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MFRS.' PUBS., cont. . .

and Bulletin GEA-3666B describes the 45-ton unit. Specifications and cost information are given on the operation of these locomotives.

Oil Testing Equipment. *Gerin Corp., P. O. Box 653, Red Bank, N. J.*—4-page Circular No. 300 describes the portable oil inspection kit produced by this company for field testing of oils. The four tests covered by this kit include gum, dirt, acidity, and viscosity.

Heating Element. *Davis Engineering Corp., 1064 East Grand St., Elizabeth 4, N. J.*—8-page Bulletin No. 20 describes the tubular heating element produced by this company for steam heating of tanks and similar vessels. Specifications and capacities are given for the various sized units which are available. Sizes produced range from 1½ to 1,040 sq.ft. of heating surface. Instructions are given for the installation of these units.

Organic Chemicals. *Eastman Kodak Co., Rochester 4, N. Y.*—This 180-page catalog, 36th edition, lists names, formulas and prices of all organic chemicals supplied by this company. First 21½ pages include new listings.

Mechanical Packings. *Packing Engineering Corp., Cranford, N. J.*—This 60-page pamphlet gives descriptions and uses of all the sealing and retaining packings produced by this company. Included in the pamphlet are 16 pages of engineering data including recommendations for most efficient packaging combinations for various services.

Cellulose Esters. *Tennessee Eastman Corp., Kingsport, Tenn.*—38-page booklet contains specifications and characteristics of standard types of cellulose acetate, cellulose triacetate and cellulose acetate butyrate together with data on their compatibility with solvents, plasticizers and resins.

Power Transmission Equipment. *Patron Transmission Co. Inc., 129 Grand St., New York 13, N. Y.*—This 192-page catalog supplies complete data, including prices, on over 5,000 items of power transmission equipment and conveyor supplies.

Steel Construction. *Lukens Steel Co., Coatesville, Pa.*—This is a 408-page reference book for engineers entitled "Steel Plates and their Fabrication." The book contains factual material on nickel-, stainless-, Inconel-, and Monel-clad steels, their physical and mechanical properties and plate and head sizes. A section of more than 100 pages of general engineering information including mathematical tables, conversion tables and other material is also included.

Plant Design and Equipment. *Industrial Process Engineers, 8 Lister Ave., Newark, N. J.*—12-page brochure describes examples of complete process units, plants, and special process equipment offered by this company. Included are absorbers, agitators of all kinds, autoclaves, blenders, condensers, crushers, crystallizers, digesters, dissolvers, drives, dryers, extruders, heat exchangers, kettles, mixers, reactors, stills and valves.

Floor Chain Conveyor. *Jervis B. Webb Co., 8951 Alpine Ave., Detroit, Mich.*—4-page folder describes the sub-floor chain conveyor system put out by this company. Other conveyors made by this company are illustrated in the pamphlet.

Surface Gas Burners. *Surface Combustion Corp., Toledo 1, Ohio.*—130-page booklet describes 60 types of surface burners put out by this company in 600 different sizes. Divided into 10 sections, the catalog is a reference source for engineers designing gas combustion equipment. The booklet include an engineering data section on furnace design and heat input requirement calculations.

Boiler Pressure Data. *Babcock & Wilcox Co., 85 Liberty St., New York 6, N. Y.*—This technical data card No 113 lists maximum allowable working pressures for the water tube and fire-tube boilers produced by this company.

Speed Changers. *Allis-Chalmers, Milwaukee, Wis.*—This 12 page Bulletin No. 20B6013-C describes the variable pitch speed changers put out by this company, showing how they are installed, maintained, and inspected. The bulletin includes data on speed range, a selection table of recom-

(Continued)

TAKE ADVANTAGE OF

Allis-Chalmers Experience!

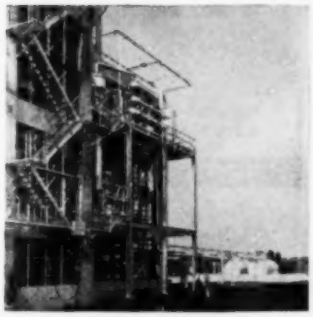
☛ You Get Sound Engineering Know-How, Production-Proved Plant Equipment, Practical Construction Data . . . When You Call on Allis-Chalmers for Your Continuous Solvent Extraction Plant.

COTTONSEED

"First of its kind in the world" — that was the newspaper story on the above cottonseed oil mill when it started production in March, 1947. It's the Delta Products Company plant for continuous solvent extraction of cottonseed oil, located in Wilson, Arkansas. Allis-Chalmers engineered and supplied equipment for this 200 ton per day mill. And production records show that it has been operating continuously and *profitably* ever since.

SOYBEANS

Here's the Tiptonville plant of the West Tennessee Soya Mill company. One building—divided into two sections—houses the preparation and solvent extraction equipment. Designed by Allis-Chalmers and equipped by Allis-Chalmers, this modern soybean oil extraction mill has been continuously operating since October, 1948. A-C equipment includes processing machinery, solvent extraction equipment and power and electrical machinery.



CORN OIL

New and highly successful, this Illinois mill is used for the continuous solvent extraction of oil from corn germ. It's another *money-saving* Allis-Chalmers installation — operating continuously since August, 1948. Processing equipment, extraction equipment and power and electrical equipment were all correlated by Allis-Chalmers to produce this efficient corn oil extraction plant. A-C engineers supervised equipment erection, employe training and initial operation.

Many Other Applications . . . The three products listed above are just a *few* of the many applications for which Allis-Chalmers continuous solvent extraction systems are being used. Successful tests have been made on milled corn, rice bran, peanuts, flaxseed, castor beans, fish meal, and *other* oil-bearing materials. Numerous plants for the continuous solvent extraction of these oils — with *Allis-Chalmers* systems — have already been built or are being constructed today. And many inquiries are coming in every week.

Learn how A-C's continuous solvent extraction system can provide greater profit in *your* vegetable oil mill. Send coupon for full information and illustrated *fact-packed* bulletin.

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Pioneers in the Field of Continuous Solvent Extraction

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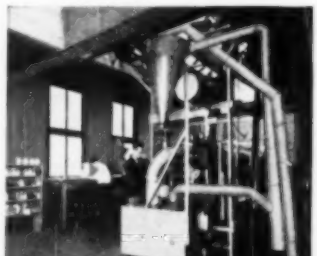
Over 1100 dryers built . . . more than 50 *different* types of products successfully dryed . . . service to nearly every major industry . . . *that's what Hersey means by "drying by experience."* And this type of experience is valuable to you because it means that, more often than not, Hersey *already* has the answer to your drying problem. If not, Hersey Engineers know where and how to find the right answer quickly. So why not save time — and money — by bringing your "unsolvable" drying problem to Hersey today?

The Mechanical Guinea Pig

where Hersey Dryers are proven BEFORE they're built!

This famous dryer — the only one of its kind — was especially constructed for test drying all types of products on a limited production basis. With only minor changes *any* type of rotary dryer can be duplicated. Here's where Hersey Engineers can give their drying theories the "acid test."



CHEMICALS

Phosphate Rock—Sodium Phosphates and Tetra Sodium Phosphates
Potassium Nitrate — Sodium Nitrate
Glaubers Salts — Bromides
Ferrous Sulphate—Anhydrous & Crystals
Sterols — Naphthoic Acid
Zinc Sulfate — Mercury Powder
Mercuric Oxide — Silica Gel
And other compounds designated by letters or numbers only.

PLASTICS

Cellulose Acetate
And others known only by trade names

FOOD PRODUCTS

Sugar—Cane—Beet—Corn—Milk—Grape — Salt
Starch—Corn—Potato—Yucca — Glutamic Acid

PROCESS WASTE

Citrus Pulp — Bagasse — Sawdust
Cranberry Waste — Sweet Potato Meal

MISCELLANEOUS

Coke — Sand
Tobacco — Hay
Poultry Manure — Concentrates
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MFRS.' PUBS., cont. . .

mended unit sizes for standard motors, general diagrams, and dimensions of pilot motor arrangements.

Plasticizers. *Monsanto Chemical Co., St. Louis 4, Mo.*—This 80-page booklet describes the properties and performance of the various types of plasticizers produced by this company. The four types described include the phthalates, phthalyl glycollates, phosphates, and sulphonamides.

Speed Reducers. *Farrel-Birmingham Co., 344 Vulcan St., Buffalo 7, N. Y.*—44-page bulletin No. 449 describes the line of speed reducers produced by this company, which are manufactured in reduction ranges from $1\frac{1}{2}$ to 1 up to 60 to 1. Engineering data and horsepower ratings for these units are included.

Cellulose Plastics. *Tennessee Eastman Corp., Kingsport, Tenn.*—42-page booklet entitled "Tenite Specifications" is the fifth edition of this booklet. It includes data on both cellulose acetate and cellulose acetate butyrate plastics. The booklet includes a complete listing of the physical properties of these plastics, and also contains a table indicating their corrosion resistance.

Plant Design and Construction. *Wigton-Abbott Corp., Plainfield, N. J.*—52-page booklet illustrates a group of the plants which this company has designed and constructed. Included are several chemical plants and research laboratories.

Tractor Shovel. *Frank G. Hough Co., 2000 Sunnyside Ave., Libertyville, Ill.*—8-page bulletin describes the $1\frac{1}{2}$-cubic yard capacity tractor shovel produced by this company. Complete specifications are given for this four-wheel drive unit, and various possible applications are pointed out.

Fatty Alcohols. *M. Michel & Co., 90 Broad St., New York 4, N. Y.*—This 8-page booklet is a guide to the properties and uses of the various fatty alcohol products produced by this company. The different products are various mixtures of the three fatty alcohols, cetyl, stearyl, and oleyl.

Pentachlorophenol. *Monsanto Chemical Co., St. Louis 4, Mo.*—This 16-page bulletin describes the technical grade of pentachlorophenol produced by this company for use in wood preservation. Methods of pressure treatment are described. The material is said to give excellent protection against underground decay.

Motors. *Elliott Co., Ridgway, Pa.*—4-page bulletin No. PB7000-1 describes the line of induction motors produced by this company in sizes from 250 to 3,500 hp. Construction details are illustrated.

Instruments. *Leeds & Northrup Co., 4934 Stenton Ave., Philadelphia 44, Pa.*—44-page catalog No. ND46(1) describes the high-speed indicators, indicating recorders, and recording controllers produced by this company. Specifications and indicated applications are given for these instruments.

Pumps. *Byron Jackson Co., Terminal Annex Box 2017, Los Angeles 54, Calif.*—16-page Bulletin No. 48-4000 describes the line of centrifugal, multi-stage, split case, volute type pumps produced by this company for medium and high-pressure service. Capacities range from 100 to 4,000 gpm., and pressures up to 2,000 ft. head.

Metallizing. *Metalweld, Inc., 26th & Hunting Park Ave., Philadelphia 29, Pa.*—4-page bulletin describes various applications for metallizing in the process industries. The various metals used are listed.

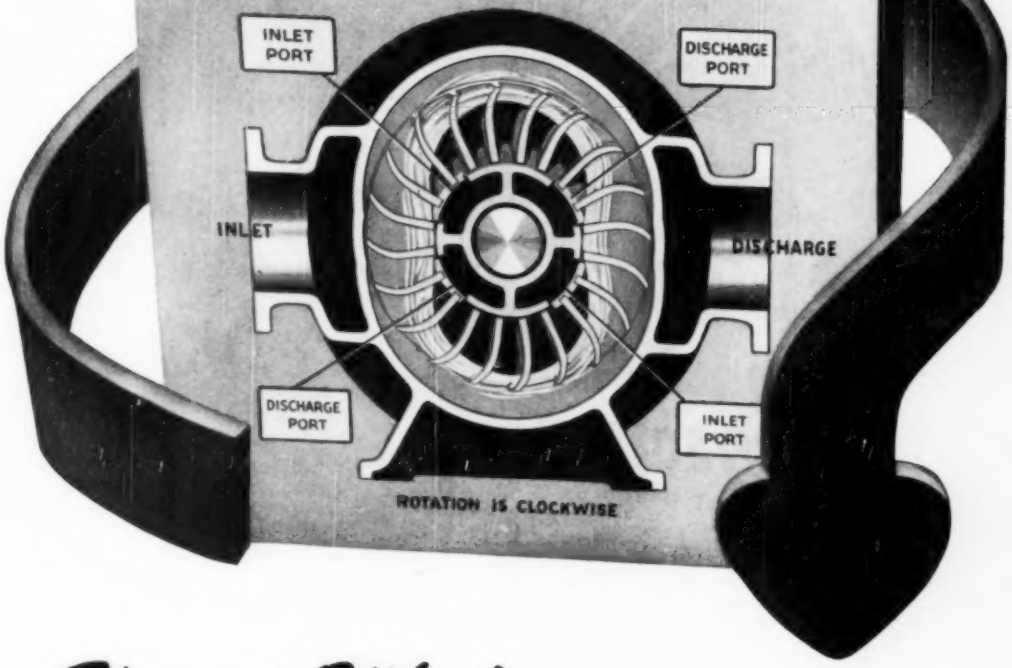
Stainless Castings. *The Cooper Alloy Foundry Co., Hillside, N. J.*—First issue of 4-page periodical called "Newscast" put out by this company gives information about the uses and properties of stainless steel castings.

Speed Reducers. *D. O. James Gear Manufacturing Co., 1140 W. Monroe St., Chicago 7, Ill.*—4-page pamphlet lists types of reducers manufactured by this company and includes tables of sizes and gear ratio carried in stock.

Stainless Steel Fabrication. *Eastern Stainless Steel Corp., Baltimore 3, Md.*—This is a 128-page technical handbook illustrating applications, giving properties and processing information of chrome and nickel stainless steels. A table of corrosion resistances of these steels is included.

—*End*

Nash Instrument Air Compressors deliver only clean air, free from oil or dust, and without filters



Here is Why!

You can dispense with oil filters and dust filters when you install ®Nash® Clean Air Compressors. You can save the cost of maintaining these devices. You can greatly reduce instrument maintenance costs. For the Nash employs no internal lubrication, therefore no troublesome oil is in the delivered air. Moreover, air from a Nash is thoroughly washed and cooled as it passes thru the pump. Dust in the plant atmosphere, even fly ash, is immediately removed.

®Nash® Clean Air Compressors are simple, with only one moving element. No valves, gears, pistons, sliding vanes, or other enemies of long life and constant performance complicate a Nash. No aftercoolers are needed. You will find it profitable to investigate these pumps, now.

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- No dust filters.
- No internal lubrication to contaminate air handled.
- No internal wearing parts.
- No valves, pistons, or vanes.
- Non-pulsating pressure.
- Original performance constant over a long pump life.
- Low maintenance cost.

NASH ENGINEERING COMPANY
373 WILSON, SO. NORWALK, CONN.

THESE DRUMS of fine chemicals are awaiting shipment in the new ultra-modern warehouse of Chas. Pfizer & Co., Inc. at Brooklyn, N. Y. Within each are products of controlled and consistent high quality. Here, in this especially constructed storage area, every effort is aimed at protecting this quality.

For example, in summer and winter, an area of 532,450 cubic feet of storage space is temperature and humidity-controlled. As much air conditioning as 50 average 6-room homes would require! Care in keeping uniform, consistently-regulated atmosphere is widespread; it includes air-lock doors, operated automatically by photo-electric cells so that warehouse interiors are not subject to temperature changes from outside air.

Here many of Pfizer's more than a hundred fine chemicals are assembled in packaged form for shipment to users. It is a source of pride that storage conditions as well as manufacturing controls contribute to Pfizer quality. Chas. Pfizer & Co., Inc., 630 Flushing Ave., Brooklyn 6, N. Y.; 211 E. North Water Street, Chicago 11, Illinois; 605 Third Street, San Francisco 7, Calif.

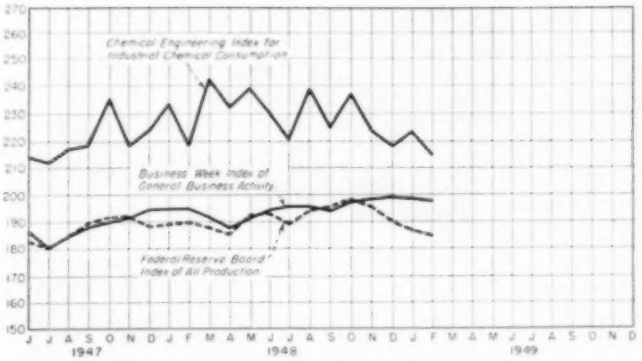
PFIZER

PFIZER QUALITY

Manufacturing Chemists Since 1849

Chemical Economics

RICHARD F. WARREN, Assistant Editor



Index Itemized

Chemical Engineering Index

Industrial Consumption of Chemicals

	January	February
Fertilizers	50.31	51.35
Pulp and paper	23.81	22.61
Petroleum refining	22.00	22.95
Glass	17.80	17.15
Paint and varnish	21.30	19.50
Iron and steel	15.00	13.70
Rayon	27.21	25.00
Textiles	10.01	9.19
Coal products	11.03	10.12
Leather	4.25	4.56
Explosives	6.66	6.65
Rubber	5.13	4.77
Plastics	8.60	8.08
INDEX	223.11	215.03

1935 = 100

Business Good But Competition Shakes Out Inflationary Kinks

Consumption of chemicals as well as other products has followed the traditional seasonal patterns so far this year. However, it is now clear that business is not moving into a serious recession this quarter or in the period immediately ahead. Early this year there were fears and predictions of a serious slump in general business that would have a bad effect on the process industries. Many who made such forecasts have since reversed or modified their estimates.

FIRST QUARTER EARNINGS

Earnings of several big chemical companies showed comfortable gains in first quarter over the corresponding period ending in March 1948. However, improvement was chiefly due to expanded capacity and not improved business. General business has been slipping a little in recent months, but this does not mean that the chemical industry is heading into a sharp recession.

Now that business has adjusted itself at levels below the postwar peaks, optimism is returning, bolstered by the knowledge that firms such as Carbide plan to continue their postwar expansions. Carbide plans to spend $80,000,000 this year on capital investments. This is a substantial amount when compared with $115,000,000 spent in 1948 on similar projects and an additional $104,000,000 expended in 1947.

However, there are definite soft spots scattered throughout the chemical process industries. Mercury salts are still facing keen competition. Many high priced items have met with serious buyer resistance and the deflation of some price structures has caused a "wait and see" attitude among consumers of some chemicals. For example, lead and zinc prices drops have reflected this resistance. Lead consumption is down about 20 percent from the postwar peak, but the recent price readjustments are expected to spur its use in pigments where it has been pricing itself out of some markets. After considering the pros and cons of the present situation the pigment industry still feels that 1949 will be a good year. Use of pigments in the paint industry will continue to keep consumption of these materials at a high level. Use of pigments in other industries will also compare favorably with levels reached in 1947.

The demand for plastics materials is improving. Some prices are dropping to come in line with competitive materials. Cellulose acetate consumption has been bucking stiff competition for some time but recent reports show some improvement in its position. Polystyrene growth has been big. Last year about 50 percent was used in synthetic rubber and the other half went into plastics. Last year it accounted for about 27 percent of total production of thermoplastic materials. Five years ago it contributed only 4 percent to the total output of thermoplastics. The new price structure is designed to keep and expand the large markets that this resin has achieved. Expansion of thermosetting resin capacities by Bakelite indicates that resin manufacturers are looking ahead to the time when the present slowdown in business is reversed and it resumes the long-term growth pattern.

RECORD STEEL OUTPUT

In April the American Iron and Steel Institute reported on the record output steel reached during the first quarter. March production was 102.7 percent of capacity or 8,388,965 tons. Total output in the first quarter was 24,053,181 tons. This was more than two million tons above the first quarter 1948 level. To illustrate the growth in steel production, the institute pointed out that production in 1945's last quarter averaged only 5,051,728 tons. April production will be above 98 percent of capacity.

The rubber industry looks forward to a good year for the rest of 1949. Herbert E. Smith, chairman of the board, U. S. Rubber Co., told stockholders that while sales were down 7 percent from the first quarter of 1948, the decline reflects an adjustment from postwar peaks to a lower level and the return to seasonal patterns. Historically, rubber sales show considerable improvement in the second over the first quarter. Mr. Smith believes that this pattern will be followed in 1949.

The **best** test meter

because it is the *most flexible*

HAGAN
Ring-Balance
FLOW METER

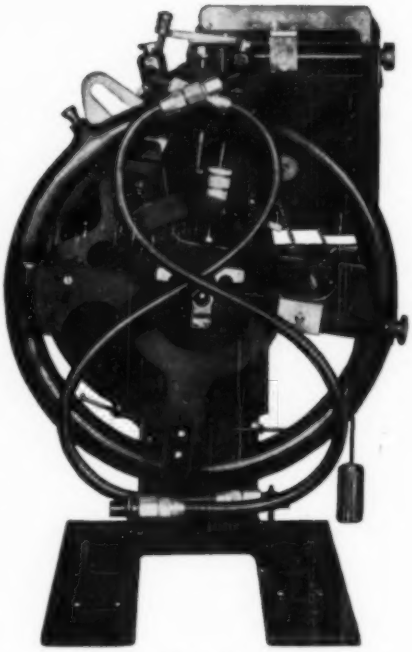
When you choose a meter for test service, you want maximum accuracy, of course. You get that in Hagan Ring Balance Meters, but you get considerably more than that. You get, among other advantages, a degree of flexibility as to differential pressures that isn't approached by any other meter.

A standard Hagan meter equipped with an R-80 ring, for example, is suitable for a range of differential pressures from 20 to 140 inches of water, and you adjust it for any differential within this range by simply turning a range screw. This feature of the adjustable meter differential permits using full scale for maximum flow on each test without altering the existing orifice. Other rings are suitable for differentials as low as ½ inch of water, and as high as 420 inches. Rings are available for static pressures up to 10,000 p.s.i.

If the test differential range is not within the present ring, it can be replaced by one having the proper range in a short time and without the use of special tools. For still greater convenience in test work, two flows may be analyzed simultaneously with the dual meter which records the two flows on a single chart.

Calibration is an important consideration in meters which are to be moved from place to place, as in test service. In Hagan Ring Balance Meters this is extremely quick and easy, requiring merely the use of check weights which are furnished with the meter. Calibration is the same for dry or wet service.

Hagan engineers will be glad to give you full information about Ring Balance Meters in relation to your own requirements. Write us about them, or fill out the coupon below.



The R-80 ring shown in this meter is suitable for differentials from 20 to 140 inches of water. Three interchangeable rings, such as the R-22 (1" to 5"), R-82 (5" to 40") and the R-98 (40" to 280") would cover a full range of differentials from 1" to 280".

HAGAN CORPORATION

RING BALANCE FLOW AND PRESSURE INSTRUMENTS
THRUSTORQ FORCE MEASURING DEVICES
BOILER COMBUSTION CONTROL SYSTEMS
METALLURGICAL FURNACE CONTROL SYSTEMS

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I am interested in the Hagan Ring Balance Meter for testing service under the following conditions:

Fluids to be metered _____ Orifice sizes _____

Differential Pressures _____ Static Pressures _____

Approximate flow _____ Flow variations _____

NAME _____ POSITION _____

COMPANY _____ ADDRESS _____ CE-5

Commodity Survey:

ETHYLENE GLYCOL

Production triple prewar

Rate as continued growth is planned

John R. Skeen

Last year production of ethylene glycol was triple the prewar level of 120 million pounds. Maximum operation of present installations can contribute a record 450 million. If announced plans materialize, an additional capacity of 50 million pounds will be available by 1950 with the possibility that this amount will be exceeded. This expansion, achieved last year in greatest part, was in response to the long unsatisfied demand for permanent type anti-freeze. Had distribution been uniform, it is probable that there would have been sufficient for the first time in six years. However, reports indicate that there is a significant carry-over of packaged goods. This causes little concern as the demand for the next anti-freeze season is placed variously up to 300 million pounds according to market experts.

VARIED OUTLETS

While the big outlet for ethylene glycol is in anti-freeze, there are many other uses. It is consumed as dinitroglycol in the manufacture of explosives, minimizing the risk of freezing without reducing product quality. The need as a coolant rapidly developed during the war in order to supply aviation motors, and penicillin and other plants. Consumption is significant in cellophane, brake fluids and radio condenser liquids. Among the newer uses may be listed such synthetic fibers as Vinyon N, introduced by Carbide and Carbon Chemicals Corp., and the Fiber A of E. I. du Pont de Nemours & Co.; glyoxal, employed by Cluett-Peabody Co. in the Sanforset process for shrink-proofing rayon; and the non-ionic polyethylene oxide detergents.

In spite of the almost constant expansion of the industry, a deficit of ethylene glycol occurred in 1941 and became increasingly serious as the war progressed. Exports were a factor for the first time and soon attained a record 71 million pounds. The demand mounted in explosives, coolants, brake fluids and cellophane. Allocations to these industries mostly signified consumption by the military. In order to supply the most urgent needs, greater yields were obtained from existing plants and the supply of glycol for anti-freeze was reduced by 75 million pounds. The alternative was to build new units and this was regarded as impractical under the circumstances. The competition in all industries for steel plate, pipe, valves and instruments was keen and the most systematic plan of distribution fell far short of satisfying all except the most urgent requirements for iron and steel. The shortage of chemical raw materials, especially chlorine and caustic, would have made facilities of doubtful value even though available.

Ethylene glycol is now made by two general methods. The modifications are several. The original chlorhydrin process is still dominant. Here ethylene is reacted with hypochlorous acid, and ethylene oxide may be recovered directly. This, upon the addition of water, yields glycol. The ethylene may derive from natural gas and gasoline in the form of concentrates boiling in the C_2-C_4 range, by cracking propane or a mixed gas stream, and by dehydrating fermentation alcohol. The alternative process consists in reacting formaldehyde with carbon monoxide and water at high temperature and pressure to give glycollic acid. Upon esterification with methanol and subsequent hydrogenation, the glycol is obtained.

COMMERCIAL HISTORY

Ethylene glycol and allied non-benzenoid chemicals present a most systematic and commercially successful history. The research was initiated at the Mellon Institute during World War I and conducted by Benjamin T. Brooks and George Curme. As a result, the Carbide and Carbon Chemicals Corp. was organized October 1920 for the express purpose of commercializing this new and specialized field of chemicals. The experimental program was transferred to Clendenin, W. Va., and consisted in reducing to industrial practice the conversion of hydrocarbon gases into glycol, acetone, ethanol and other valuable products. Five years later, this operation was moved to South Charleston, W. Va., and has remained in continuous production since.

(Continued)

Ethylene Glycol: A Statistical Summary

	Production									
	Total[1] 1,000 Lb.	Chlorhydrin[2] Percent of Total	Exports[3] 1,000 Lb.	Capacity[4] 1,000 Lb.	Plants[5] Number	Producers[6] Number	Price[7] Tanks, N. Y.	Chlorine Required Percent of Total	Use: Lb. per Auto Unit[8]	Anti-Freeze Percent Total Glycol
1935	.....	100	n. a.	.....	1	1	$0.155	....	1.90	...
1936	82,000	100	n. a.	115,000	2	2	0.16	15.5	2.24	77
1937	102,000	99	n. a.	....	2	2	0.16	....	2.62	76.5
1938	140,000	....	n. a.	160,000	2	2	0.152	....	2.96	62
1939	120,000	90	n. a.	165,000	2	3	0.15	15.0	2.84	72.5
1940	133,000	....	n. a.	220,000	3	4	0.135	10.5	3.19	77
1941	151,543	67	7,545	235,000	3	4	0.135	....	3.66	83
1942	195,000	....	62,020	....	6	4	0.141	....	1.49[9]	25
1943	186,834	56	71,426	270,000	5	3	0.125	6.5	1.59[9]	26
1944	202,451	....	32,850	....	5	3	0.09	....	3.99[9]	59.5
1945	205,087	....	23,580	.....	5	3	0.08	....	3.98	59
1946	192,176	....	14,081	270,000	5	3	0.09	7.5	3.69	65
1947	226,679	....	18,117	.....	5	3	0.11	....	4.28[10]	70.5
1948	362,237	56	10,874	440,000	7	5	0.133	10.0	5.72[10]	65

[1]1941, 1943 and after: U. S. Tariff Commission, Annuals and Facts for Industry, series 6-2; values for other years are estimates only. [2]Represented by Carbide, Dow, U. S. Industrial Chemicals, Jefferson Chemical, Wyandotte. [3]U. S. Foreign Commerce and Navigation; 1946—: Report No. FT410; imports have been no factor in the industry. [4]Approximations only; limiting factors have been the chlorine supply and the competition for ethylene oxide; these estimates regard total available capacity less other production as from ethylene oxide and assume sufficient chlorine. [5]Exclusive of Standard Alcohol, 1938-40; in chronological sequence, plant locations are S. Charleston, W. Va., Midland, Mich., the U. S. I. plant—1939-42, Texas City, Tex., Belle, W. Va., Wyandotte, Mich., Midland, Mich., the U. S. I. plant—1939-42, Texas City, Tex., Belle, W. Va., Wyandotte, Mich., Port Neches, Tex. [6]In sequence: Carbide, Dow, U. S. I., Du Pont, Wyandotte, Jefferson. *Oil, Paint and Drug Reporter*. [7]Pounds of glycol produced for sale as anti-freeze divided by the number of units of passenger cars, trucks and buses registered December 31 of the cited year; production for anti-freeze are estimates; registrations, courtesy Automobile Manufacturers Association; assumption is made that all anti-freeze goes to these automotive units introducing an error which may be as much as 8 percent in late years (tractors, engines and other outlets). [8]Based upon WPB opinion that 48.5 million lb. of glycol was consumed in anti-freeze. [9]Facts for Industry, series 6-8-14 gives 119,874,000 lb. glycol consumed almost entirely consumed in anti-freeze. [10]Industry Report, October 1948 states that 168 million lb. glycol were used in anti-freeze. [11]Estimates range from 186 million lb. (Ind. Report) to 230 million lb.; 235 million lb. used here although the carry-over of packaged goods may total 23 million lb.

Dr. Skeen is head of the Market Research Department of Foster D. Snell, Inc., New York.

Outstanding among its great variety of mineral resources readily available for chemical manufacturing is Oklahoma's tremendous reserve of high grade silica, in several forms:

Glass Sand. Equal in chemical quality to any in the United States and used by glass plants in Oklahoma and adjacent states since 1918.

Tripoli. This state has long been an important supplier of tripoli, in 1944 ranking third in national production.

Novaculite. Outcroppings of more than 100 square miles in southeastern Oklahoma are a continuation of the outcrops in southwestern Arkansas where novaculite has been produced for many years and where chemical analysis shows silica content to be 99% or more!

Vein Quartz. Very large deposits of milky variety are easily accessible.

Chat and Slimes. Millions of tons of highly silicious material are available as by-products of zinc mining in northeastern Oklahoma.

TYPICAL ANALYSIS OF SILICA GLASS SAND FROM ARBUCKLE MOUNTAINS

Average of Plant Run — 1947

SiO_2	99.829
Fe_2O_3	0.036
Al_2O_3	0.072
CaO	0.009
MgO	0.005
L. O. I.	0.072
Total	100.023

Detailed information on Oklahoma's mineral resources is available on request, based on data by the Oklahoma Geological Survey. Map showing location of mineral deposits is also available.

COMMODITY SURVEY, *cont.* . .

The value of glycol was first thought to be in the solvent field. However, it was introduced in 1922 as a substitute for glycerine in the manufacture of low freezing dynamite. Consumption soon became 3 million pounds annually. Perhaps for these reasons, the promotion of glycol was stressed at South Charleston. The first great market was soon found in anti-freeze. Small amounts were sold in 1925 by the associated Prest-O-Lite Co. Two years later, sales were transferred to National Carbon Co. However, it was soon observed that untreated solutions were corrosive to radiator metals. This necessitated the addition of anti-corrosive and anti-leak agents as well as a foam preventive. The combination became Prestone. About this time, Glycol was in demand in the manufacture of electrolytic condensers and as a plasticizer for cellophane. The essential features of the present end use pattern appeared early.

CHLORINE SUPPLY

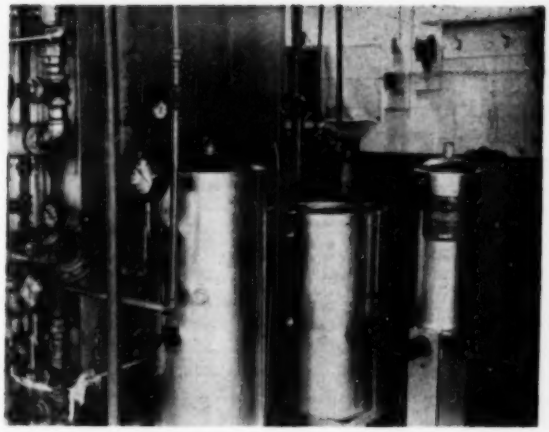
The necessary chlorine was supplied by contract with Westvaco Chlorine Products Co. The rapid growth of ethylene glycol was a major contributing factor in making that company the largest producer of chlorine in the early 30's. Even so, there was not always sufficient to permit the operation of ethylene oxide facilities at a maximum. Accordingly when Carbide expanded it was by way of the direct catalytic oxidation of ethylene. The domestic rights to the Lefort patent were acquired from the Societe Francaise De Catalysee Generalisee in 1936 and the process was operating on a small scale at South Charleston the next year. This process has been expanded. In 1941 it was installed at Carbide's Texas City, Tex., plant.

Others soon entered this field. U. S. Industrial Chemicals, Inc., began in 1939 and this led to a rather celebrated patent suit with Carbide. While this was eventually decided in favor of Industrial, the war caused the price of molasses to rise beyond the break-even point and so forced Industrial to discontinue after a few years. Meantime, Dow Chemical Co. erected a plant at Midland, Mich., followed by a second at Freeport, Tex. The new Du Pont process began 1940 at Belle, W. Va. Last year the plants of Jefferson Chemical Co. and Wyandotte Chemical Co. were operating at Port Neches, Tex., and Wyandotte, Mich. Carbide began in this field and continued alone for 30 years. Today, Carbide accounts for about half of the production followed by Dow, Du Pont, Jefferson and Wyandotte.

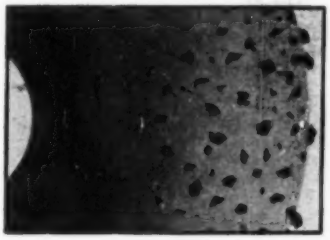
—*End*

Filters that Make a Record for Fidelity

This machine applies a coating of cellulose acetate to discs made by Wilcox-Gay Corporation used for home recording. Cuno MICRO-KLEAN Filter removes contaminants, down to 1 micron in size, to insure the flawless coating needed for high-fidelity playback. MICRO-KLEAN cartridges have set new records by running longer without replacement.



Guaranteed fluid conditioning . . . double cartridge life



Positive Cleaning . . . Greater Capacity

Cuno is the only manufacturer of replaceable-cartridge filters *guaranteeing* to remove all solids larger than specified, plus a large proportion down to 1 micron. MICRO-KLEAN's exclusive "graded-density-in-depth" permits smaller particles to penetrate to varying depths, eliminates surface loading, *doubles dirt holding capacity*. Resinous impregnation and polymerization prevents channeling, rupturing, shrinking and distortion.

Wide Range of Applications

Cuno MICRO-KLEAN filters come in varying densities . . . capacities from a few to more than 800 gpm . . . connections from ⅜ in. IPS to 6 in. flanged . . . single or multiple cartridges to handle full flow. MICRO-KLEAN cartridges fit other makes; special lengths available for built-in installations.

● Your nearby Cuno engineering representative, handling the broadest line of fluid filters, is your best source of unbiased recommendations on fluid filtration . . . he offers you, before and *after* installation, service based on years of experience with engineering filtration systems.

CUNO

Fluid Conditioning

Removes More Sizes of Solids from More Types of Fluids

MICRONIC • DISC-TYPE • WIRE-WOUND

Send Coupon

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Cuno Engineering Corporation
1018 S. Vine St., Meriden, Conn.

Please send information on Cuno Filter.

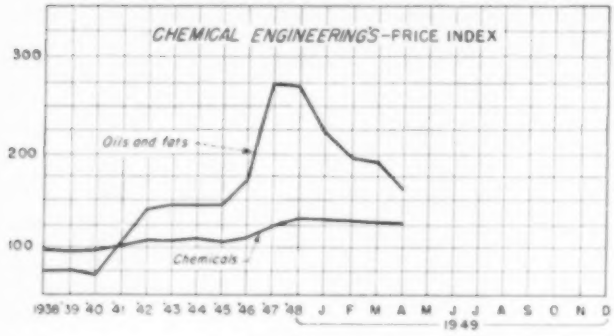
Name.....

Position.....

Business Address.....

PLEASE ATTACH COUPON TO YOUR BUSINESS LETTERHEAD

PRODUCTION, CONSUMPTION AND PRICE TRENDS



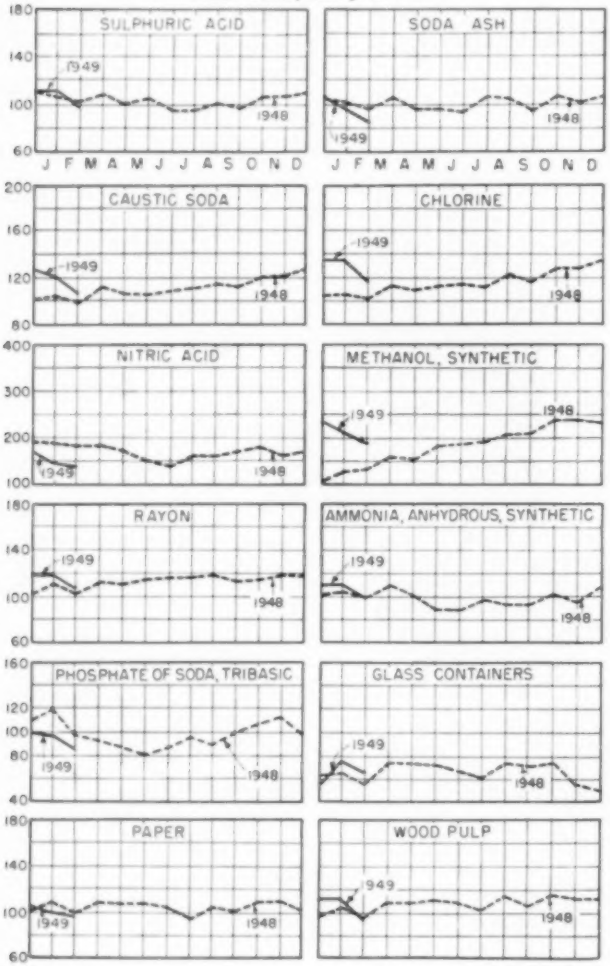
Weighted Index

Chemical Engineering Index of Prices

	Chemicals	Oils & Fats
As of May 1	123.59	167.96
Last Month	126.06	163.61
May 1948	131.11	289.53
May 1947	122.90	272.16

1937 = 100

100 = Monthly Average for 1947



Price Trends

Chemical prices continued their downward movement in April and by May 1 *Chemical Engineering's* index for chemicals was down to 123.59. However, the fats & oils index rallied and by the end of April it reached 167.96. Dioctyl phthalate dropped to 41¼c. per lb. Prices of mercury salts were weak late in April. Hand-to-mouth buying is generally conceded to be creating most price weaknesses, as consumers use up their inventories. Some fats and oils, such as cottonseed oil, bounced back slightly during April.

Production Trends

Production of industrial morganic chemicals fell off again in February. However, the production rate was generally the same as that reached in February 1948. In April the Bureau of the Census reported on the production of 35 industrial chemicals. Of these 17 were produced in quantities above the February 1948 level and 15 were below that rate. Among the large volume chemicals, production gains over January were reported only for synthetic ammonium sulphate. Production of this chemical reached an all time high in February and was 15 percent above the 52,856,000 lb. reported in December.

Lion Oil Co. reports that the demand for all chemical products of the company including fertilizers continues to exceed the supply. T. H. Barton, chairman of the board, pointed out that production of ammonia by the company has been increased by more than 25 percent. In addition, ammonium nitrate facilities are being expanded along with sulphuric acid and ammonium sulphate units. All these facilities will be operating in the next quarter.

Separating solid from solvent this new way saved time, materials, costs

ANOTHER A.T. & M. SUCCESS STORY BY Sam Spinner
"SAM, OUR PROBLEM IS TO SEPARATE A SOLID FROM A COSTLY SOLVENT, RECOVERING BOTH. IT MUST BE A FAST, LOW-COST PROCESS."
"THAT'S A TOUGH ONE, BUT I THINK I'VE GOT THE ANSWER . . ."
"WE'VE PUT A FUME-PROOF HOOD ON A REGULAR A.T.&M. CENTRIFUGAL. THE HOOD ROUTES ALL SOLVENT VAPORS TO A CONDENSER WHILE CENTRIFUGAL FORCE SEPARATES SOLID AND SOLVENT."
"LIQUID SOLVENT DRAINS OUT TO RECOVERY TANKS, WHILE THE SOLID IS PLOWED OUT THE BOTTOM INTO CONTAINERS. SOLID, LIQUID AND VAPOR ARE RECOVERED ALMOST 100%."
3 MONTHS LATER
"THAT FUME-PROOF CENTRIFUGAL DID THE TRICK, SAM. IT SURE BEATS SETTLING TANKS AND FILTERS FOR SPEED AND EFFICIENCY."
"YOU BET IT DOES. A.T. & M. CENTRIFUGALS ARE TAKING OVER MORE AND MORE CHEMICAL PROCESSING JOBS, DOING 'EM FASTER, BETTER, AT LESS COST."

SAVE TIME, SPACE AND COSTS WITH

A.T. and M. CENTRIFUGING

AMERICAN TOOL & MACHINE COMPANY
1415 Hyde Park Ave., Boston 36, Mass.

Please send information on centrifuging applied to the following processes:
☐ Extraction ☐ Filtration ☐ Dehydration ☐ Coating ☐ Precipitation
☐ Sedimentation ☐ Impregnation

Write here any other process .....

Name ..... Title .....

Company .....

Street .....

City ..... Zone ..... State .....

Let us bring you up to date on what *modern* centrifuging can do. JUST MAIL COUPON . . . NO OBLIGATION

no CHEMICAL can attack TEFLON PACKING

FOR PUMPS AND VALVES

Installed in December 1947 . . .

STILL GOOD

on pumps handling fuming sulphuric acid!

The Koppers Company has Worthington Worthite pumps to handle fuming sulphuric acid. They used conventional packing, had to repack every two days. Then in December 1947 the pumps were packed with TEFLON—and haven't needed repacking SINCE!

No. 101 Plastic TEFLON Packing is non-porous, has the 100% chemical resistance of pure TEFLON. Withstands temperatures from minus 80°F to 525°F. Style 201 same as 101, except mica is substituted for graphite. Use 201 for stainless steel valves and pumps. We also make TEFLON covered gaskets.

Wherever, whenever you have a nasty packing or gasket problem, call on

POWER PRODUCTS CO.
11 Broadway, New York 4, N.Y.

United States Production of Certain Chemicals

January 1949, January 1948

Chemical (Tons unless otherwise noted)	January 1949	January 1948
Ammonia, synthetic, anhydrous[1]	99,057	95,405
Ammonium nitrate	83,707	95,357
Ammonium sulphate, synthetic (M lb.)	47,770	35,252
Calcium arsenate (M lb.)		
Calcium carbide, commercial	61,918	58,091
Carbon dioxide:		
Liquid and gas (M lb.)	18,871	16,384
Solid (M lb.)	41,500	40,741
Chlorine	152,838	123,319
Chrome green (M lb.)	780	958
Chrome yellow and orange, (C.P.) (M lb.)	3,958	4,076
Hydrochloric acid	39,370	39,089
Hydrogen (M cu. ft.)	2,552	2,202
Lead arsenate, acid and basic (M lb.)	3,866	3,229
Molybdate chrome orange, (C.P.) (M lb.)	446	490
Nitric acid	97,854	103,834
Oxygen (M cu. ft.)	1,403	1,271
Phosphoric acid (50 percent H_3PO_4)	112,969	95,331
Soda ash:		
Ammonia-soda process:		
Total wet and dry[2]	372,224	383,481
Finished light[3]	205,400	189,627
Finished dense	110,102	136,512
Natural[4]	17,133	22,389
Sodium bicarbonate, refined	13,546	13,190
Sodium bichromate and chromate	8,913	7,664
Sodium hydroxide:		
Electrolytic process:		
Liquid[5]	150,994	119,061
Solid	28,161	25,170
Lime-soda process:		
Liquid[5]	58,897	62,717
Solid	22,670	20,974
Sodium phosphate:		
Monobasic	1,120	1,068
Dibasic	11,407	6,563
Tribasic	6,679	8,125
Meta	2,847	2,512
Tetra	6,162	4,949
Sodium silicate, anhydrous	35,914	37,529
Sodium sulphate:		
Anhydrous	16,596	13,015
Glauber's salt[6]	14,712	18,457
Salt cake[6]	57,710	51,999
Sulphuric acid[6, 7]	964,506	932,933
Chamber process	247,968	285,734
Contact process, new	652,345	597,119

Data for this tabulation have been taken from "Facts for Industry" series issued by Bureau of the Census. Production figures represent primary production and do not include purchased or transferred materials. Quantities produced by government-owned arsenals, ordnance works, and certain plants operated for the government by private industry are not included. Chemicals manufactured by TVA, however, are included. All tons are 2,000 lb. Where no figures are given data are either confidential or not yet available. [1]Includes a small amount of aqua ammonia. [2]Total wet and dry production, including quantities diverted for manufacture of caustic soda and sodium bicarbonate, and quantities processed to finished light and finished dense. [3]Not including quantities converted to finished dense. [4]Data collected in cooperation with the Bureau of Mines. [5]Figures represent total production of liquid materials, including quantities evaporated to solid caustic and reported as such. [6]Includes oleum grades, excludes spent acid. [7]Data for sulphuric acid manufactured as a byproduct of smelting operations are included.

United States Production of Synthetic Organic Chemicals

January 1949, January 1948

Chemical	January 1949	January 1948
Acetanilid	567,082	444,334
Acetic acid:		
Synthetic[1]	38,661,620	31,892,953
Recovered	36,608,315	142,756,264
Natural[2]	2,344,605	2,296,288
Acetic anhydride[3]	66,519,676	62,700,326
Acetone	43,863,924	36,944,596
Acetylsalicylic acid	1,179,868	979,411
Aniline	7,136,417	9,488,617

(Continued on page 364)

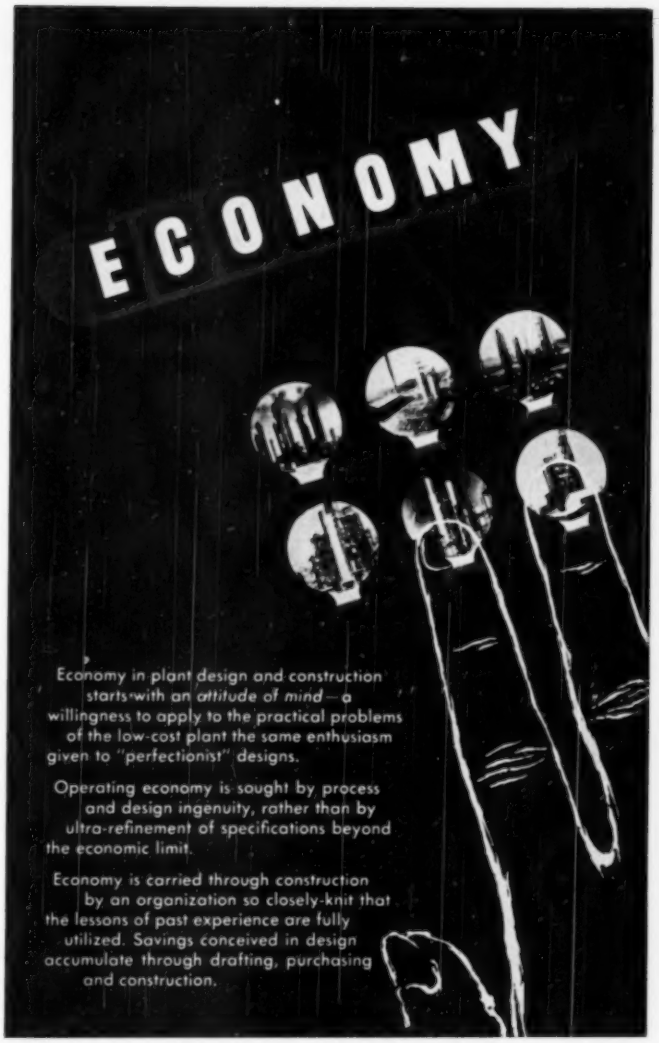
Get all the Facts you need on

ACE-O-PAX PACKAGED RING SETS for Chemical Pumps

PACKAGED RING SETS for Worthington Worthite Chemical Pumps, Duriron and LaBour Chemical Pumps are the most efficient and economical sets of chemical packing on the market. These sets are composed of the proper number of rings of Style 28M or 30M, molded to exact dimensions for the unit, individually boxed and labeled. They save your operators time in repacking; they save waste of packing; and they will reduce your inventory of packings.

WRITE TODAY FOR CATALOG AND PRICE LISTS.

PACKING ENGINEERING CORP.
279 Lincoln Ave., Cranford, New Jersey


ECONOMY
Economy in plant design and construction starts with an attitude of mind—a willingness to apply to the practical problems of the low-cost plant the same enthusiasm given to "perfectionist" designs.
Operating economy is sought by process and design ingenuity, rather than by ultra-refinement of specifications beyond the economic limit.
Economy is carried through construction by an organization so closely-knit that the lessons of past experience are fully utilized. Savings conceived in design accumulate through drafting, purchasing and construction.

ECONOMY by prototype—

Time, rather than money, was the major concern when the first of these wartime butadiene plants was built. Successful in design and operation, it was the prototype for two additional plants, saving *both* time and money in construction. All have exceptional records of low operating cost.

ECONOMY by experience—

In furnishing plants for the production of ethlyene, Lummus has combined its petroleum and chemical plant experience. High yields and low product cost per dollar of investment have been obtained, along with wide-range flexibility as to charge stock composition. Total capacity of Lummus ethylene plants is now some half-million pounds per day.

ECONOMY by expediency—

This smaller customer had rigid limits of first cost for its lube oil plant. Lummus accepted the challenge—the design was developed to permit use of existing and rebuilt equipment—located and purchased by Lummus for the job. This plant was completed exactly on schedule, and neutrals of zero pour test were ready for shipment on the second day of operation.

THE LUMMUS COMPANY
420 Lexington Avenue, New York 17, N. Y.

LUMMUS

CHICAGO—600 South Michigan Avenue, Chicago 5, Ill.
HOUSTON—Mellie Esperson Bldg., Houston 2, Texas
The Lummus Company, Ltd.
525 Oxford St., London, W-1, England
Société Française des Techniques Lummus
39 Rue Comban, Paris 1er, France
Compañia Anónima Venezolana Lummus
Edificio "Las Gradillas"
Esquina Las Gradillas, Caracas, Venezuela

designs and builds with ECONOMY

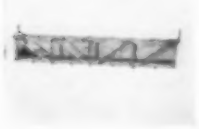
Fulfillment
Teamwork
Resourcefulness
Perspective
Technique

complete FOR SERVICE

consult

Cambridge

ON FABRICATED WIRE ASSEMBLIES FOR BULK HANDLING & PROCESSING



Special fixtures for heat treating and other processes.

Woven wire slings reduce accidents—simplify bulk handling and shipping of pipes, tubes, shapes, etc.

Cambridge offers the engineering and fabricating facilities to supply you with baskets, trays, racks, crates or specialized fixtures in any metal or alloy . . . custom-built for your particular requirements.

Cambridge wire fabrications are "job-fitted" for all types of bulk handling and processing to insure maximum efficiency.

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Cambridge Wire Cloth Co.

Dept.G · Cambridge 5, Md.

Wire cloth in rolls. | Any metal or alloy, mesh or weave.

OFFICES IN PRINCIPAL INDUSTRIAL CITIES

U. S. Production of Synthetic Organic Chemicals, cont. from page 362

Chemical	January 1949	January 1948
Barbituric acid derivatives[2]		
5-Ethyl-5-phenylbarbituric acid and salts (phenobarbital)	39,276	61,772
Benzene:		
Motor grade:		
Tar distillers[4]		
Coke-oven operators[5]	647,949	1,210,717
All other grades:		
Tar distillers[4]	1,020,321	1,178,998
Coke oven operators[5]	12,743,849	12,842,769
Butyl alcohol, primary, normal	11,306,633	11,146,280
Carbon bisulphide	36,786,754	30,150,133
Carbon tetrachloride	18,537,625	18,638,275
Chlorobenzene, mono	28,511,102	28,608,266
Creosote oil:		
Tar distillers[4]	10,884,738	9,510,471
Coke-oven operators[5]	2,252,712	3,332,032
Cresols, meta-para	666,555	382,893
Cresols, ortho-meta-para	867,697	611,428
Cresylic acid, refined[7][10]	2,302,157	1,908,753
Dibutyl phthalate	1,056,611	2,304,827
Dichlorodiphenyltrichloroethane (DDT)	3,349,716	2,331,546
Ethyl acetate (85 percent)	5,560,177	5,290,792
Ethylene glycol	33,908,347	23,007,536
Ethyl ether	2,741,231	2,424,177
Formaldehyde, 37 percent by wt	68,875,043	53,497,372
Hexachlorocyclohexane	1,159,795	1,317,958
Methanol, natural[4]	1,314,693	1,455,382
Methanol, synthetic	95,134,181	47,394,535
Naphthalene:		
Tar distillers, less than 79° C.	25,499,765	14,142,778
Tar distillers, 79° C. and over	7,225,039	9,009,590
Coke-oven operators, less than 79° C.	8,979,031	8,531,934
Penicillin and salts[8]	10,477,729	6,901,355
Phenol	26,767,011	25,973,126
Phthalic anhydride	16,294,597	12,433,117
Styrene, government and private plant	33,015,962	26,005,410
Toluene:		
Coke-oven operators	2,540,306	2,427,900
All other[9]	3,978,468	3,744,034
Xylene, crude	4,812,933	3,359,083

All data in pounds except benzene (gal.) creosote oil (gal.), toluene (gal.) xylene (gal.) and penicillin (million Oxford units). Statistics collected and compiled by U. S. Tariff Commission except where noted. Absence of data on production indicates either that returns were unavailable or confidential. [1]Excludes the statistics on recovered acid. [2]Acid produced by direct process from wood and from calcium acetate. All acetic anhydride including that from acetic by vapor-phase process. [4]Product of distillers who use purchased coal tar only or from oil-gas or water-gas produced or purchased by tar distillers. [5]Statistics are given in terms of bulk medicinals only. [8]Statistics collected by Bureau of Mines. [7]Total production including data reported both by coke-oven operators and by distillers of purchased coal tar. [9]Reported to U. S. Bureau of the Census. [10]Includes toluene produced from petroleum by any process. [10]Includes refined cresylic acid from petroleum.

HERE'S A *New* AUTOMATIC CONTROL VALVE

. . . cylinder operated Diaphragm Type

1 . . . **Powerful:** cylinder operated (pneumatic or hydraulic)
2 . . . **Reliable:** ASCO 3-way Pilot Control Solenoid Valve
3 . . . **Protected:** rubber lined contact parts

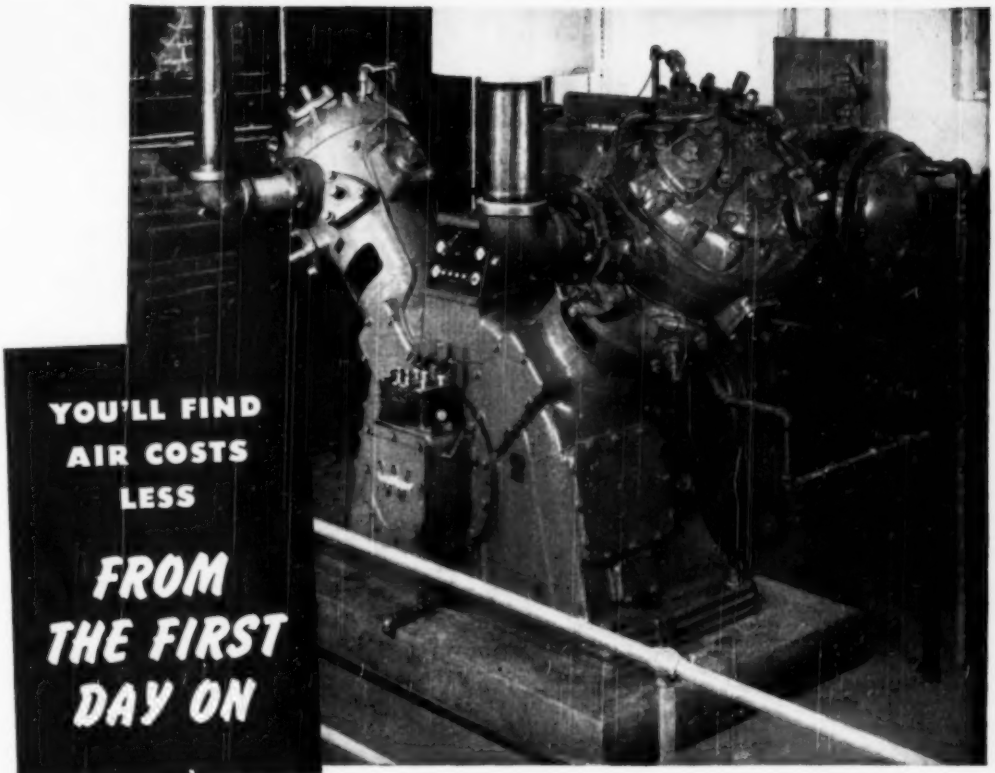
This control valve unit consists of a Saunders Patent type natural or synthetic rubber lined diaphragm type main valve with a rugged and powerful operating cylinder suitable for air or hydraulic operation. **It is controlled by an ASCO 3-way Solenoid Pilot Valve.** All components are assembled into one compact unit as in the 1" flanged connected unit illustrated. Sizes range from ½" to 3". We shall be glad to send you further information on this control valve; also our Condensed Catalog No. 200-R which describes briefly our complete line of Solenoid Operated Valves.

When in need of Automatic Transfer Switches, Remote Control Switches, Contactors, Relays, and Specialized Electromagnetic Controls, come to us.

ASCO Solenoid VALVES

Automatic Switch Co.

381 Lakeside Avenue • Orange, New Jersey



You save with the Worthington YC Compressor—right from the start.

It arrives completely assembled. Installation cost is low, because there's no alignment problem. No erecting engineer needed. Just make the air and power connections and it's ready for work.

You save on space, too. The YC needs only one-half the building space and one-quarter the foundation space of same-capacity horizontals.

There's more operating economy for you in the balanced Y-frame construction for higher rpm and the famous Worthington Feather* Valves—most efficient ever made.

And for years to come you'll benefit from maintenance savings. Valves are unusually accessible; openings are large for quick inspection; spare parts are smaller, less expensive. And finally, you'll always pay less for power, due to the YC's instantly responsive 3- and 5-step *variable capacity control*.

WRITE FOR DETAILS

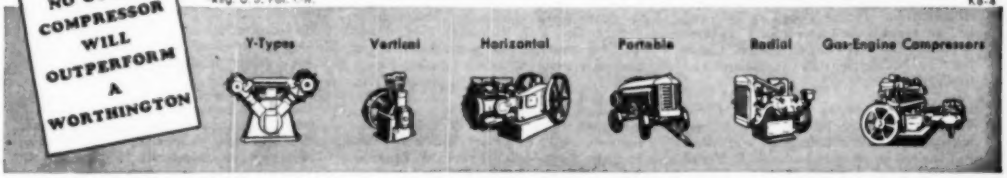
that show how Worthington YC Compressors can reduce your air costs. Bulletin L-667-B1A has the facts that prove *there's more worth in Worthington. Worthington Pump and Machinery Corporation, Compressor Division, Buffalo, New York.*

WORTHINGTON

NO OTHER COMPRESSOR WILL OUTPERFORM A WORTHINGTON

*Reg. U. S. Pat. Off.

K8-4



New Construction

	Current Projects		Cumulative 1949	
	Proposed Work	Contracts	Proposed Work	Contracts
New England	$68,000	$130,000	$274,000	$1,056,000
Middle Atlantic	.....	1,343,000	158,233,000	4,461,000
South	1,450,000	68,000	3,603,000	20,206,000
Middle West	1,000,000	1,070,000	11,654,000	21,221,000
West of Mississippi	850,000	4,763,000	34,443,000	31,062,000
Far West	.....	2,679,000	3,825,000	1,478,000
Canada	10,350,000	34,800,000	27,815,000	47,400,000
Total	$13,718,000	$44,853,000	$239,937,000	$126,944,000

Proposed Work

Ga., Albany—Dixie Leather Corp., c/o Graton & Knight Co., 356 Franklin St., Worcester, Mass., plans to construct a tannery to have capacity of 6,000 hides weekly. Estimated cost $1,000,000.

Ill., Decatur—A. E. Staley Mfg. Co., Decatur, plans to construct a soybean oil extraction plant to employ hexane washing process. Estimated cost $1,000,000.

Iowa, Des Moines—Iowa Farm Bureau Federation, Farm Bureau Bldg., plans to construct a fertilizer plant. Estimated cost $850,000.

Mass., Dartmouth—Carbide & Carbon Chemical Corp., 205 East 42nd St., New York, N. Y., plans to construct a 1 story pyrofax plant. Estimated cost $68,000.

S. C., Winnsboro—U. S. Rubber Co., 1230 6th Ave., New York, N. Y., plans to construct a laboratory here. Estimated cost $250,000.

Va., Richmond—The Hinde & Dauch Paper Co., c/o Carneal & Johnston, Archts., 1000 Atlantic Life Bldg., Richmond, plans to construct a 313x428 ft. factory to include stock storage building, power house and shipping platform. Estimated cost $200,000.

Alta., Edmonton—Consumers Exploration Co., Ltd., Leduc, plans to construct an oil refinery. Estimated cost $350,000.

Alta., Red Deer—Alberta Pulp Mills, Ltd., Red Deer, plan to construct a pulp mill for the manufacture of newsprint and fine paper. Cellulose Engineers, Ltd., 71 Columbia St., Seattle, Wash., Eng. Estimated cost $10,000,000.

Contracts Awarded

Calif., East Los Angeles—Clorox Chemical Co., 850 42nd Ave., Oakland, has awarded the contract for a 1 story, 120x263 ft. factory to Wm. P. Neil Co., 4814 Loma Vista Ave., Los Angeles. Estimated cost $130,000.

Calif., San Francisco—General Paint Corp., 2627 Army St., has awarded the contract for a synthetic resin manufacturing unit to Barret & Hilp, 918 Harrison St. Estimated cost $200,000.

Calif., San Francisco—Kortick Manufacturing Co., 345 First St., has awarded the contract for a galvanizing plant to Fred Scheil, 666 Mission St. Estimated cost $88,000.

Calif., San Francisco—Pacific Gas & Electric Co., 245 Market St., will construct a 17,000,000 cu. ft. gas holder. Work will be done by owners. Estimated cost $2,191,375.

Conn., Hartford—Hartford Gas Co., 233 Pearl St., has awarded the contract for a gas plant to United Engineers & Constructors, Chestnut St., Philadelphia, Pa. Estimated cost $130,000.

Idaho, Pocatello—Westaco Chemical Corp., 405 Lexington Ave., New York, N. Y., will construct an addition to its plant here. Work will be done by separate contracts. Estimated cost will exceed $70,000.

Minn., Minneapolis—Newhouse Paper Co., 515 Washington Ave., N., has awarded the contract for a 1 story, 56x147 ft. warehouse to W. A. South Co., 120 South St. Estimated cost $68,000.

N. J., Bound Brook—Research Corp., 405 Lexington Ave., New York, N. Y., has awarded the contract for a 1 story plant to Michael Riesz & Co., 871 King Georges Rd., Fords. Estimated cost $1,000,000.

N. J., Carteret—Westaco Chemical Corp., 405 Lexington Ave., New York, N. Y., will enlarge its plant here. Work will be done by separate contracts. Estimated cost will exceed $150,000.

N. J., Eagle Point—The Texas Co., 134 E. 42nd St., New York, N. Y., has awarded the contract for an oil separator building and concrete drainage basin to H. John Homan, 434 Haddon Ave., Collingswood, N. J. Estimated cost will exceed $125,000.

O., Akron—B. F. Goodrich Co., 500 South Main St., has awarded the contract for a factory to Hughes-Foulkrod Co., 1505 Race St., Philadelphia, Pa. Estimated cost $1,000,000.

O., Columbus—Columbus Plastic Products Co., 1625 West Mound St., has awarded the contract for an addition to its factory to Columbus Construction Co., 348 North High St. Estimated cost $70,000.

Okla., Witcher—Peppers Refining Co., First Natl. Bldg., Oklahoma City, will construct a natural gasoline plant in Witcher Oil field. Work will be done with own forces. Estimated cost $1,000,000.

Pa., Chester—Scott Paper Co., foot of Market St., has awarded the contract for altering Bldg. No. 71 to David M. Hunt, 1700 Sansom St., Philadelphia. Estimated cost $68,000.

S. C., Taylors—Southern Bleachery & Paint Works, Taylors, has awarded the contract for a treatment plant to Peden Construction Co., Greenville, at $68,246.

Tex., Agua Dulce—Panhandle Producing & Refining Co., City Natl. Bank Bldg., Houston, has awarded the contract for a gas compressor plant to Jones & Laughlin Supply Co., 108 North Trenton St., Tulsa, Okla. Estimated cost $1,000,000.

Tex., Baytown—Humble Oil & Refining Co., Baytown, will reconstruct its Butyl plant finishing room. Work will be done by owners. Estimated cost $85,000.

Tex., Corpus Christi—Southwest Texas Pipe Line Co., Tribble Rd., will enlarge its refinery. Work will be done by owners. Estimated cost $85,000.

Tex., El Campo—The Texas Co., 720 San Jacinto St., Houston, has awarded the contract for cooling tower, compressor and generator buildings, including 3600 hp. compressors to Tellepson Construction Co., 1710 Telephone Rd., Houston. Estimated cost $475,000.

Tex., Karnes City—United Gas Pipe Line Co., Alamo Natl. Bldg., San Antonio, has awarded the contract for a natural gas processing plant to Delta Engineering Corp., 1616 Bell St., Houston. Estimated cost $475,000.

Tex., Kenedy—Archer-Daniels Midland Flax Processing Plant, Kenedy, has awarded the contract for a linseed oil refinery to Newman Construction Co., Kenedy. Estimated cost $100,000.

Tex., Port Neches—B. F. Goodrich Rubber Co., 500 South Main St., Akron, O., has awarded the contract for plant expansion to Carruth Contracting Co., c/o A. E. Dishman, 5795 Port Arthur Rd., Beaumont. Estimated cost $750,000.

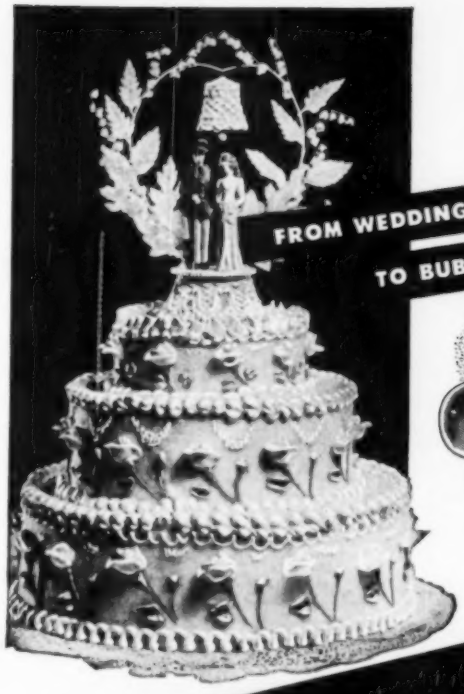
Tex., Texas City—Carbide & Carbon Chemical Corp., Texas City, has awarded the contract for enlarging its chemical plant to Ford, Bacon & Davis, Texas City. Estimated cost $600,000.

Tex., Wichita Falls—Panhandle Refining Co., P. O. Box 1191, has awarded the contract for warehouse and welding and machine shops at its refinery to Jones & Laughlin Supply Co., 108 North Trenton St., Tulsa, Okla. Estimated cost $125,000.

B. C., Abbotsford and Kilgard—Clayburn Co., Ltd., 850 West Hastings St., Vancouver, has awarded the contract for a fire brick plant here, also rebuilding plant at Kilgard, to Clayburn Co., Ltd., 850 West Hastings St. Estimated cost $800,000.

B. C., Ketchikan—American Viscose Co., Wards Cove, has awarded the contract for the construction of a wood pulp mill to Morrison-Knudsen Co., Inc., 319 Bway., Boise, Idaho. Estimated cost $30,000,000.

Que., Shawinigan Falls—Canadian Industries, Ltd., 1135 Beaver Hall Hill, Montreal, has awarded the contract for a cellophane plant to Fraser-Brace Engineering Co., Ltd., 360 St. James St., Montreal. Estimated cost $4,000,000.



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Because—Glycerine is a wholesome humectant . . . retaining freshness, improving texture in cakes and breads . . . avoiding graining in icings, toppings, marshmallow fillings . . . preventing hardening in jams, jellies, candies, chewing gums.

Because—Glycerine is a food . . . digesting normally to supply energy in much the same way as sugars and fats.

Because—Glycerine is a solvent and blending agent . . . improving the palatability, sharpening the distinctive tastes of flavoring preparations. Glycerine is a sweetening agent, a preservative. Its well-proved versatility can be matched by no other product.

That's why in the food industry—and in *all* industry—for today's products—and for tomorrow's—*Nothing takes the place of glycerine!*

GLYCERINE PRODUCERS' ASSOCIATION
295 Madison Avenue
NEW YORK 17, NEW YORK

Technical GLYCERINE NEWS

COMPRESSED FOODS THAT ARE FRIABLE. Major problem of compressed food manufacturers is friability. One answer is the use of a small quantity of glycerine prior to compression. The glycerine is said to produce a firm product which can be easily broken when ready for use. (F-1)

★ ★ ★

A NON-TOXIC REFRIGERANT. A refrigerant mixture, particularly suited for use with foodstuffs because it has no objectionable taste and is edible, may be prepared from glycerine and water. (F-2)

★ ★ ★

NEW SUBSTITUTE FOR CORKS. Closures for foodstuffs may soon be m .de with a new cork substitute in which glycerine is an essential ingredient. The new product is claimed to have bulk density and resilience comparable to natural cork. (F-3)

★ ★ ★

GLYCEROL VISCOSITIES TABLE AVAILABLE. Miner Laboratories, headquarters for the Glycerine Producers' Association program of glycerine research, has prepared a table of viscosities of glycerol in aqueous solution from 0 to 100 per cent, at from 0 to 100 degrees C. You can obtain your copy by checking item F-4 on the coupon below. (F-4)

★ ★ ★

SECRET OF NEW QUICK-METHOD CAKES. The potent ingredient in the new quick-method cakes is a shortening containing a glycerine compound. This shortening makes possible the use of more sugar and milk to improve the cake. (F-5)

★ ★ ★

PLANT SAFETY HINT. If your workers use safety goggles, glycerine is a must. It's one of the best anti-fogging agents—and it's a good lens cleaner, too. (F-6)

GLYCERINE PRODUCERS' ASSOCIATION, DEPT. 4
295 MADISON AVENUE
NEW YORK 17, N. Y.

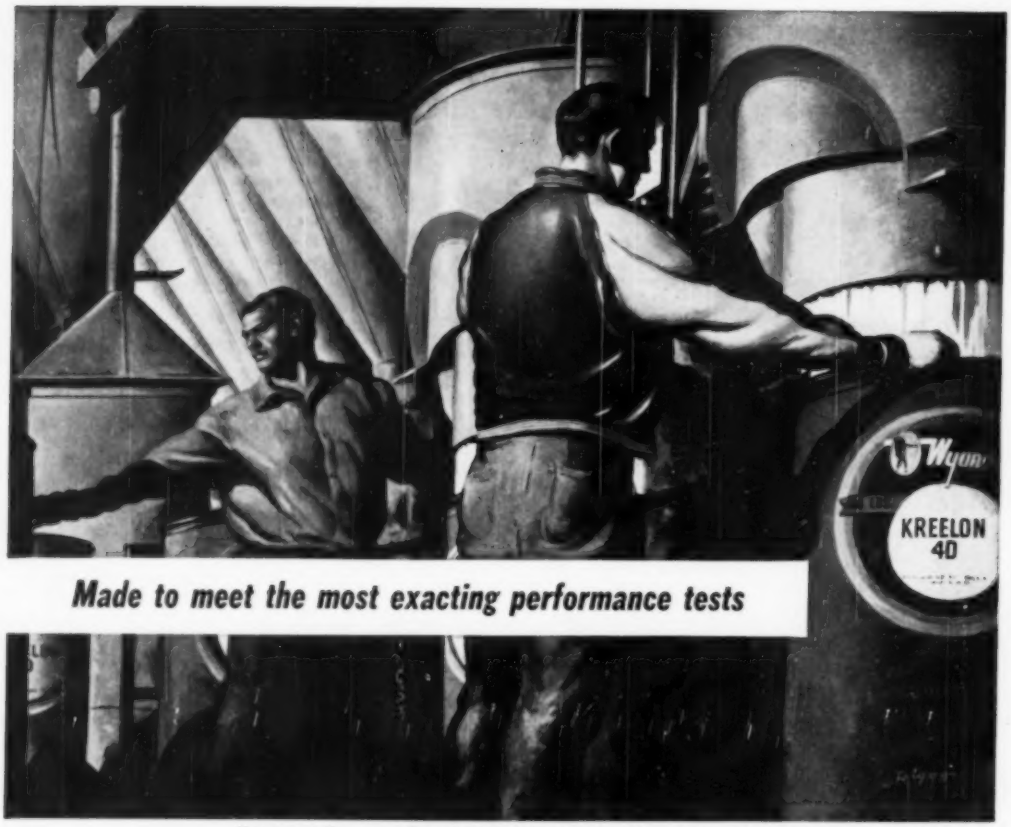
I should like to receive more information on the source of the items appearing in *Technical Glycerine News*. I have checked below those items which interest me.

☐ F-1 ☐ F-2 ☐ F-3 ☐ F-4 ☐ F-5 ☐ F-6

NAME .....

COMPANY .....

ADDRESS .....



Made to meet the most exacting performance tests

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WYANDOTTE KREELON—*the white, uniform detergent and wetting agent*

If you produce cleaning compounds or other products that call for an effective synthetic organic detergent, you'll find the answer in *Wyandotte Kreelon*®. Or if some operation in your plant requires an unusual amount of time and labor in the wetting-out process, chances are that Kreelon can help you do a *better job, faster.*

This versatile chemical, broadly classified as a surface-active agent, is designed to meet rigid performance specifications. Initial production of Kreelon was delayed for months until the product's color, chemical analysis and performance measured up to the highest standards. Controlled production maintains these standards.

The three grades of Kreelon produced range from *white* to *light cream* in color and have only a faint characteristic odor. Equally important is the fact that they retain their wetting, sudsing and cleansing properties in acid, alkaline or neutral solutions — in hard or soft waters.

Wyandotte Kreelon is readily available and economically priced. Complete information on its properties and suggested uses will be furnished at your request. In addition, our experienced technical staff stands ready to assist you in solving many detergency problems.

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Wyandotte, Mich. • *Offices in Principal Cities*

SODA ASH • CAUSTIC SODA
BICARBONATE OF SODA
CALCIUM CARBONATE • CALCIUM CHLORIDE
CHLORINE • HYDROGEN • DRY ICE
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CARBOSE (Sodium CMC) • ETHYLENE DICHLORIDE
PROPYLENE DICHLORIDE • CHLOROETHERS
AROMATIC SULFONIC ACID DERIVATIVES
OTHER ORGANIC AND INORGANIC CHEMICALS

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Dress up your bulk shipments in

Decorated LEVERPAK DRUMS

choice of (17) colors . . . choice of (14) inks

NOW YOU CAN deliver your dry bulk products in style—make them part of your package "family"... traveling billboards through all stages of use and reuse.

Continental can supply you with improved Leverpak drums in any of seventeen eye-catching colors. We can reproduce your name and trademark in any of fourteen different inks. And there's no waiting for this service. We're set up to start the drums rolling your way as soon as you give us the word.

LEVERPAKS—unpainted or in colors—are the best-looking, most serviceable fibre shipping drums we have ever turned out. They load compactly and ride safely. The patented locking device is easy to open, easy to close. Metal chimes are flash butt welded for greater strength.

If you want a sturdier container . . . one that will "dress up" your bulk shipments, contact our nearest office for full details on Leverpak and other Continental drums.

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Barrett phthalic anhydride is a pure white flake product of unsurpassed excellence and uniformity.
Its molten color is practically water-white . . . and it retains this color far longer than any normal requirement for processing in plant kettles.
It is free from materials which cause premature gelling and foaming, and it contains a minimum of fines, insuring uniform reaction speeds which are slow and easy to control.
It is ready for use, and because of its free-flowing properties, it can be fed directly to processing equipment.
It is available in 5-ply paper bags containing 80 lbs. which can be used as the unit in formulating, avoiding the necessity for storing in open containers and cutting time-wasting weighing or measuring.
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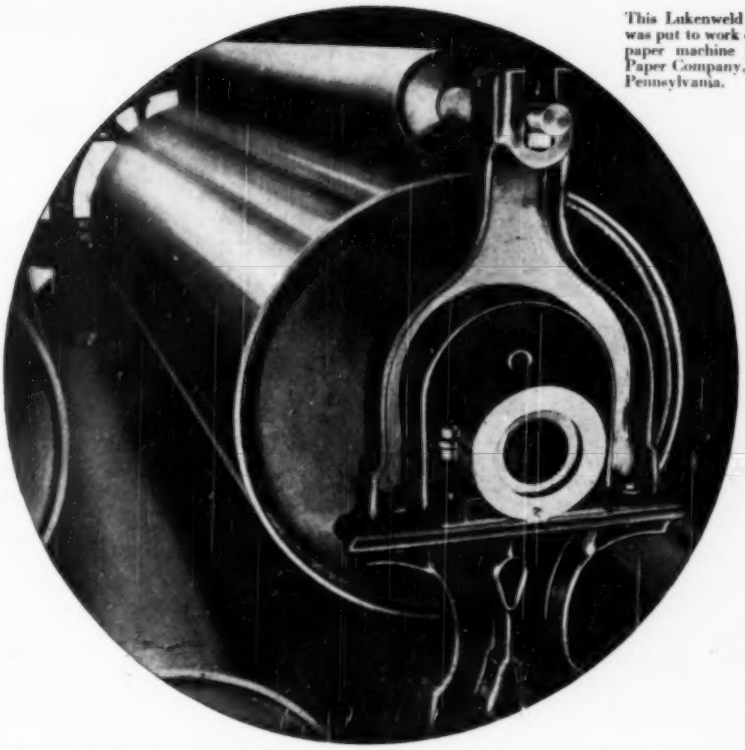


This Lukenweld Steel Drier Roll was put to work early in 1934 on a paper machine at Downingtown Paper Company, in Downingtown Pennsylvania.

This Lukenweld Steel Drier Roll has stayed *round* through 14 years of service

Recently removed for the repair of a worn journal caused by faulty lubrication, this 14-year-old roll gave Downingtown Paper Company's engineers an opportunity to check every detail. Their findings confirmed these facts, similarly proved by previous examinations of dozens of other Lukenweld Rolls:

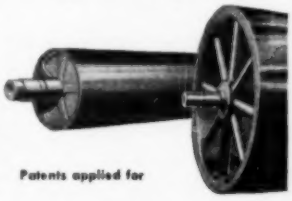
STABLE DIMENSIONS. Although in use on a paper machine ever since 1934, this 42" Lukenweld Steel Drier Roll is still round to within a tolerance of 0.004". (The machining tolerance was ±.005".) The tolerance has scarcely changed in over 14 years.

LONG-LIVED. On the interior surfaces of the chamber in which steam circulates, there were no evidences of corrosion.

STRONG AND SAFE. After the journal was repaired, this Lukenweld Roll was ready to go back to work, sound as the day it was installed 14 years ago.

Hundreds of Lukenweld Jacketed Steel Drier Rolls, at work in various industries, have proved they dry faster, better and safer. *Faster* because of reduced wall thickness and higher efficiency. *Better* because surface temperatures are even and constant. *Safer* because of their welded steel construction—steam pressures as high as 350 psi are permissible.

For Bulletin 358 giving data on drier rolls, or for help on complete machines, write Lukenweld, Division of Lukens Steel Company, 400 Lukens Building, Coatesville, Penna.



Patents applied for

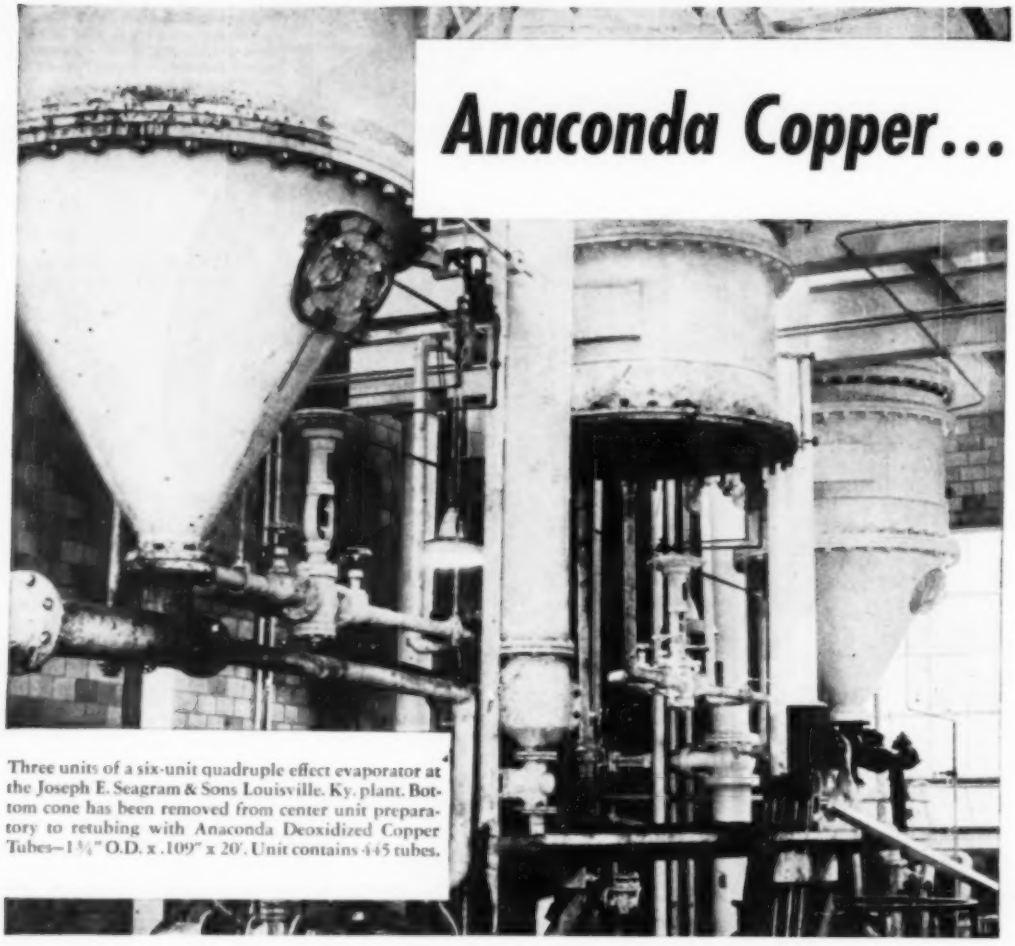
We'll lend you "LUKENWELD", a 16mm motion picture with sound, highlighting our methods, facilities and products. Running time: 20 minutes. Write for booking date.

LUKENS
LUKENWELD DIVISION

DESIGNERS, ENGINEERS AND MANUFACTURERS OF MACHINERY

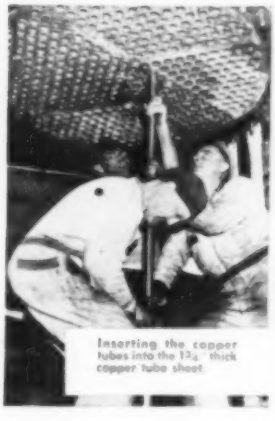
• • SPEED SCRAP TO THE MILLS TO MAKE MORE STEEL • •

Anaconda Copper...



Three units of a six-unit quadruple effect evaporator at the Joseph E. Seagram & Sons Louisville, Ky. plant. Bottom cone has been removed from center unit preparatory to retubing with Anaconda Deoxidized Copper Tubes—1¾" O.D. x .109" x 20'. Unit contains 445 tubes.

Copper Tubes Go Into 6-Unit Evaporator in Seagram's Plant, Louisville, Ky.



Inserting the copper tubes into the 1¾" thick copper tube sheet

Manually expanding copper tubes into tube sheet at bottom of still-age evaporator.

These modern evaporating units are being retubed with Anaconda Deoxidized Copper to obtain the most in heat transfer efficiency, non-contamination of product *and* long-range economy.

This evaporator receives its feed from dewatering screens and presses at 130° F. The feed is approximately 4% solids—in suspension and dissolved. The liquid is fed at 9,000 gallons per hour to the 4th effect evaporator and continuously fed to the other effects in a backward feed. Final concentrations take place in forced circulation evaporators. 3.34 lb. of water are evaporated per pound of steam. Total evaporation: about 70,000 lb. per hour.

Old Hand at solving New Problems

FOR WELL OVER A CENTURY, copper from The American Brass Company has been solving problems in the manufacture of stills, vats, storage tanks, heat exchangers, pipe lines—and a host of other types of chemical and processing equipment.

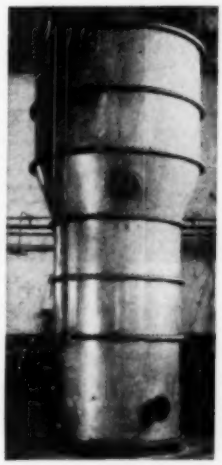
To provide the most efficient service in each application, Anaconda furnishes several types of copper having distinctive chemical and physical properties. These include Electrolytic (Tough Pitch) Copper, Deoxidized Copper, and several others.

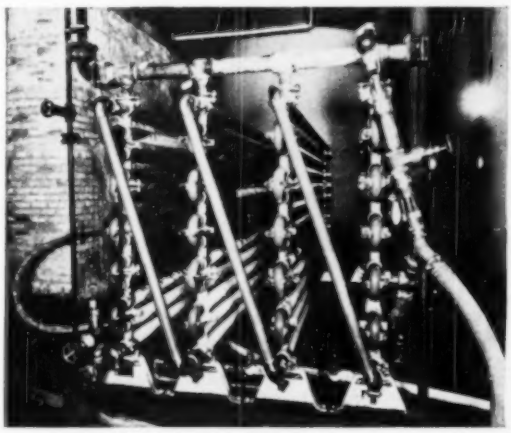
In specifying Anaconda Copper, consider the relative importance of: weldability, workability, electrical and thermal conductivity, operating temperature range and corrosion resistance. Then consider the type of Anaconda Copper to serve best in your application.

Whatever your problem, if it involves copper or any copper alloy in wrought form, remember that the facilities of our Technical Department are maintained for *your* benefit. Users, designers and fabricators of processing equipment are invited to ask for this service.

Badger Builds with Copper

The Badger Manufacturing Company, Cambridge, Mass., fabricated this 20-foot-high aldehyde exhausting column from Anaconda Deoxidized Copper, .109" gage. Bubble caps are made from the same material. Diameters of the column are 72" and 102". One of the 72" sections, showing the bubble caps, is shown below.





Enzinger Union Lines Steel Tubes with Copper

This highly efficient double pipe cellar beer cooler uses Anaconda Copper Tubes. For brine service, the inner tubes are of seamless hard drawn copper; for ammonia service, the tubes are of seamless steel with a seamless copper lining spun or drawn into place, so as to make a closely bonded joint between steel and copper. Return bends are of bronze. Beer comes in contact only with the bronze and copper, while the ammonia coolant contacts only steel. Copper and bronze were chosen for high heat transfer and ease in working. The double pipe cooler is made by Enzinger Union Corporation, Angola, New York.

ANACONDA

Anaconda

COPPER & COPPER ALLOYS

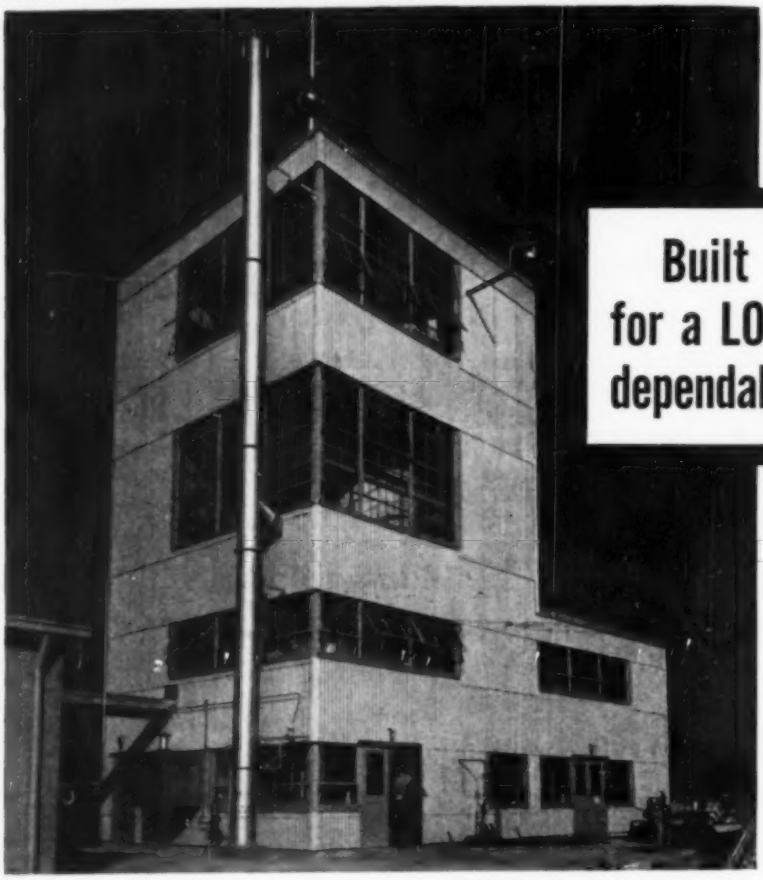
THE AMERICAN BRASS COMPANY

General Offices: Waterbury 88, Connecticut

Subsidiary of Anaconda Copper Mining Company

In Canada: Anaconda American Brass Ltd., New Toronto, Ont.

• *New pilot plant of Pittsburgh Consolidation Coal Company at Library, Pa., sided with "Century" Asbestos Corrugated. Construction by Chemical Plants Division of Blaw-Knox Company, Contractors.*



Built for a LONG life of dependable service

K&M "Century" ASBESTOS CORRUGATED

Nature made asbestos... Keasbey & Mattison has made it serve mankind since 1873

This large pilot plant of the Pittsburgh Consolidation Coal Company is the latest unit in one of the most modern research laboratories of its kind. The new building is designed and equipped for the study and development of more efficient coal gasification processes.

It is fitting that the fine equipment of this pilot plant should be housed in a modern building sided with good-looking, long-lasting K&M "Century" Asbestos Corrugated. This time-proved material is noted for great structural strength and ability to withstand severe commercial usage. It resists fire, weather, rot, rust and galvanic action. And no protective painting or upkeep is needed.

"Century" Asbestos Corrugated is easy to cut with a portable electric or band saw . . . easy to drill . . . easy and *fast* to apply, for it comes in 24 different sheet lengths. Can be re-used even after many years of service.

Write for name of nearest distributor and further particulars. Your inquiry will receive prompt attention.

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"Give us the tools . . ."

The 81st Congress Can Halt the Administration's *SOCIALIST PROGRAM*

In his speech at Massachusetts Institute of Technology, Winston Churchill said that America's possession of the atomic bomb is all that has kept Soviet Russia from overrunning Europe and bombing London.

Our State Department knows that there has been another deterrent to aggressive warfare by Russia and a deciding one. That deterrent is the superior industrial strength of the United States. But once Russia approaches our industrial strength, then watch out! For Stalin or no Stalin, there will be trouble. Therefore, the simple table below is worth every American's careful reading. It shows in percentages what Russia did with her national income in 1948 and what we did with ours:

	USSR	USA
Civilian use	60%	79%
New capital equipment and public works	21%	12%
Foreign aid		2%
Defense	13%	5%
Building of inventories and war stock-piling	6%	2%

These figures for Russia come from *The* (London) *Economist*, Britain's influential economic journal.

These figures are estimates based on information from behind the Iron Curtain, and so cannot be checked directly. But they fit with what is known of Russian development.

The table shows that Russia is straining every resource to build up its industrial strength. When Russia's effort is measured in *dollars*, and compared to ours, the figures show:

Where we spent $20 to $21 billion for new industrial plants and equipment last year, the Russians spent $12 to $14 billion.

But while we used about $9 billion of this to *replace* old equipment, the Russians spent no more than $2 billion for replacing old equipment. The Russians had much less worn-out and obsolete equipment to replace. They could concentrate their efforts on expanding their industries and buying new equipment.

So—we used only $11 to $12 billion to *expand* our industries.

And the Russians used almost as much to expand theirs—$10 to $12 billion.

Russia is gaining industrial strength as fast as we are—and may soon be gaining faster. The more she gains and the faster she gains on us, the greater is the danger of war.

continued on next page

American industry is pushing modernization and expansion hard. It is doing an heroic job. McGraw-Hill's recent survey* shows that *industry* already has in hand plans to build plants and buy equipment in the next five years adding up to $55 billion. Industry plans that investment—*and much more—if it can get the money.*

On those plans of *industry* depend *our* national security.

If these plans of ours are cut back, the Russians will be years closer to their goal of industrial equality—the strength that they need to wage aggressive war successfully.

But more and more our industry's plans are being menaced by socialist policies in Washington. The President continues to urge a further increase in the tax on corporate profits, even though federal taxes alone now take 38 cents of every dollar of profit. He wants $3 billion more in taxes on corporate profits now, plus added personal taxes.

Last year corporations spent almost two-thirds of their profits—about $13 billion—for new plant and equipment. This year corporation profits will be lower than last year's $21 billion, perhaps by 20 per cent. Subtract a fifth or more from last year's profits. Then adopt the President's proposal and take $3 billion more in corporate taxes and you raise havoc with planned expenditures for new plant and equipment.

Approval by Congress of the President's tax program would cut industry's program of plant and equipment development by a third or more. That means a major blow to our prosperity as well as our national security. For as capital investment goes, so goes general prosperity.

Further serious damage would be done by Congressional approval of the President's industry-control bill. The so-called Stability Act of 1949 (the Spence Bill) would severely check industrial progress. That bill would put the federal government in the business of providing the added industrial capacity which the tax program would prevent private industry from doing for itself. It would be hard to conceive a better and surer way to dry up private investment in new plant and equipment. For every dollar of government investment will scare away many times more dollars of private investment. People will not want to risk their money in businesses competing with the U. S. Treasury. At the same time it will attack private investment in another way. It means that government would spend your income for you instead of allowing you to spend or invest for yourself. That is the high and quick road to socialism.

American industry needs right now great courage and incentives if it is to carry out its tremendous building program. It needs also a release from the program of a socialist administration in Washington with its systematic discouragement of enterprise and risk taking.

Above all, industry needs assurance by the actions of the 81st Congress itself that there is a future in this country for a system of dynamic capitalism, functioning in a free society. By acting now to strengthen the American people's faith in their industrial system, by providing needed incentives for management and investors, by protecting industry's capacity to buy new equipment, the 81st Congress can sustain American industrial progress and keep us united and strong.

But if we kill freedom of industrial planning and action by unneeded taxes and government controls we put ourselves—and our friends all over the world—in dire peril.

Nothing would please the Communists more.

James H. McGraw, Jr.

President, McGraw-Hill Publishing Company, Inc.

***A complete report on our national survey may be obtained by writing McGraw-Hill Publishing Co., 330 West 42nd St., New York 18, N. Y. This is one of a special series of editorials on industry's needs for new plants and equipment.**

"SO YA want to cut costs?"

Soya can!

...says Mr. fatty acid!

That's a punishable pun, sure enough. But you'll forgive our obese friend completely, when you hear the story. Because you *can* cut costs remarkably with ADM's new distilled soybean fatty acid—RO-10.

If you are making protective coatings, you'll marvel at the splendid drying properties of RO-10. And for soaps, alkyds, printing inks, insecticides, waxes, metal working compounds, putty, cements and similar products, RO-10 has a combination of values that *you simply can't duplicate at comparable cost.*

Soybeans offer one of the finest, cheapest, most plentiful sources of commercial fatty acids. Now, out of ADM's long experience in soybean chemistry, RO-10 emerges as a major new material for industry. Want literature describing RO-10, and our new chart comparing scores of other fats and oils? Just mail the coupon below.

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Please send the material checked: ____ New bulletin on Soybean Fatty Acids, ____ Bulletin No. 77 showing properties of Fatty Acids in handy chart form.

We are particularly interested in these materials for the uses checked:

( ) SOAPS ( ) RUBBER PROCESSING ( ) MINERAL
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New Reports from Users

Showing Typical Results on Corrosion-Control Problems where *Carpenter* STAINLESS No. 20 is used

Corrodent PRIMARY CONSTITUENT	REMARKS	PROCESS	RATING
Aluminum sulfate plus alumina	245°F.	Mfg. of aluminum sulfate.	Excellent, no sign of pitting after 35 working days.
Concentrated chlorine solution	— —	— —	Type 304 pitted. No. 20 satisfactory.
Fluoborate Plating Solutions	— —	Electroplating copper, zinc, etc.	Recommended for use in any of the commercial fluoborate plating solutions.
Maleic acid	30% concentration	— —	Excellent (better than Type 316).
Phosphoric acid	70% phosphoric 5% sulfuric some hydrofluoric boiling acid at 135°C.	— —	Excellent. Corrosion rate obtained: .0180 IPY.
Sulfuric acid	15/50% H_2SO_4 at room temperature	Nozzle for filling storage batteries.	Excellent.
Sulfuric acid	2 to 3% H_2SO_4 room temperature to boiling	Pickling tank.	Under severe working conditions Carpenter Stainless No. 20 showed no appreciable loss of weight due to corrosion (.00012 IPY).
Sulfuric acid	93% H_2SO_4 saturated with sulfur dioxide	— —	Excellent. Negligible corrosion rate (.00006 IPY).
Sulfuric acid	1% to 105% H_2SO_4	Die manufacturing. Heat exchanger coils.	Approx. 8 times as resistant as lead. Expected equipment life 4 years with Stainless No. 20.
Sulfuric acid	10% solution 140/160°F.	Acid dip pickling process.	Excellent.
Wet Chlorine Gas	— —	— —	Not recommended.
Zinc Phosphate	Solution contained approx. 5% sodium chloride at 180°F.	— —	Estimated life 10 to 30 times that of Type 302 or 304. Total exposure during test: 460 hours.

THIS TECHNICAL BULLETIN *describing Carpenter Stainless No. 20 and its properties is yours for the asking. For your copy, just drop us a note on your company letterhead.*

THE CARPENTER STEEL COMPANY
127 West Bern Street, Reading, Pa.

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Licensed under patents of The Duriron Co., Inc.

New Products . . .

*from Pittsburgh's "Isle of Chemicals"**

and more to come!

1 PIPE LINE ENAMEL PLANT

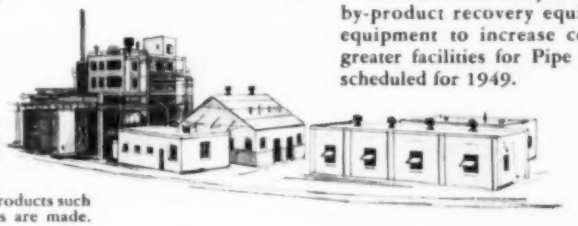
The new Pipe Line Enamel Plant where the company's own tar is converted into bituminous protective coatings of wide usefulness to industry and utilities.

2 AGRICULTURAL CHEMICAL PLANT

The new Agricultural Chemical Plant manufactures a variety of chemicals for weed control, insect and pest control, plant growth regulation and similar agricultural applications.

3 PHTHALIC ANHYDRIDE PLANT

In full operation, this new Plant takes Naphthalene from the by-product coke ovens and converts it into Phthalic Anhydride from which many products such as resins and plasticizers are made.



The policy of constantly expanding the facilities of Pittsburgh Coke & Chemical Company—for producing a greater variety of "finished" chemicals—moved closer to its goal in 1948. The program, in 1949, will continue unabated.

To the *Pittsburgh* line of coal-chemicals, these recently completed operating units have added bituminous protective coatings, such as Pipe Line Enamels for the protection of gas and oil transmission lines; a wide range of Agricultural Chemicals such as insecticides, herbicides, fungicides and rodenticides; and Phthalic Anhydride from which certain resins and plasticizers are made.

An additional battery of 35 new coke ovens, with by-product recovery equipment, new grinding equipment to increase cement production and greater facilities for Pipe Enamel production are scheduled for 1949.

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Grant Building · Pittsburgh 19, Pennsylvania

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COAL CHEMICALS · ACTIVATED CARBON · NEVILLE COKE · EMERALD COAL · PIG IRON · GREEN BAG CEMENT · CONCRETE PRODUCTS

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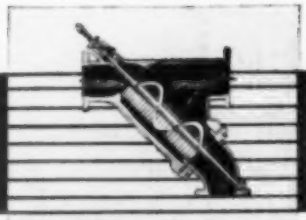

PAINT, WAX STEAM . . . OR ANY LIQUID

WITH SARCO SCRAPER STRAINERS

Any liquid that can flow through a pipe can be free from impurities down to any size screen you select, with the Sarco Scraper Strainer. It's the last step and a final insurance of the product just before packaging. In the paint plant illustrated, a Sarco is on each of the three tanks in front of the automatic canning machine. The strainer screens are cleaned every few hours by a turn of the handle.

In a large metal plant, exhaust steam from hammers, formerly unusable because of the lint and dirt, is now used for heating. Food syrups, river water and hot wax are other applications.

Standard Sarco Strainers are made in four types, ¼" to 8" for pressures up to 900 pounds. Scraper strainers ¾" to 8" and 200 pounds, hand or motor operated. Ask for Catalog Nos. 1200 and 1225.

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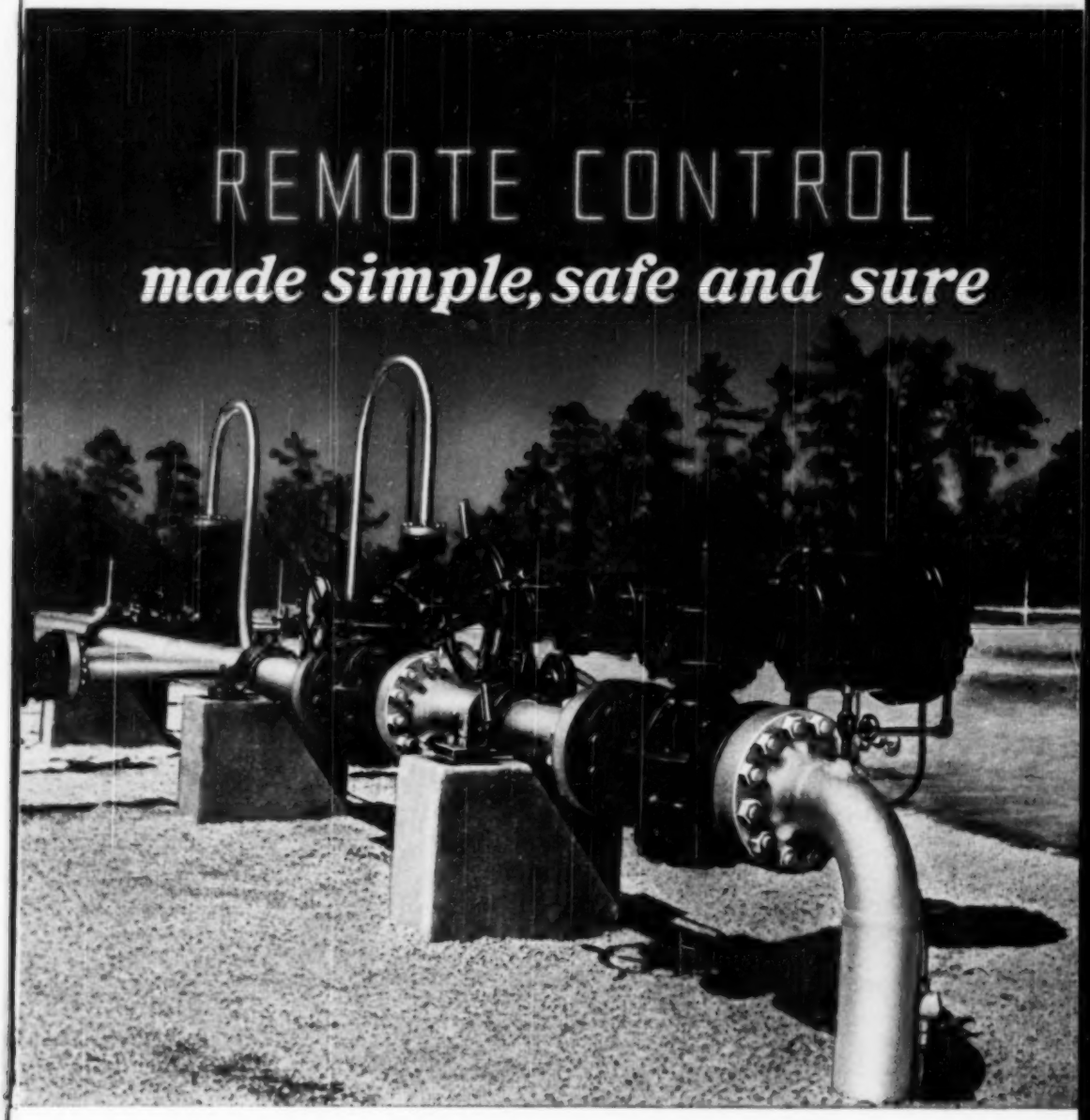
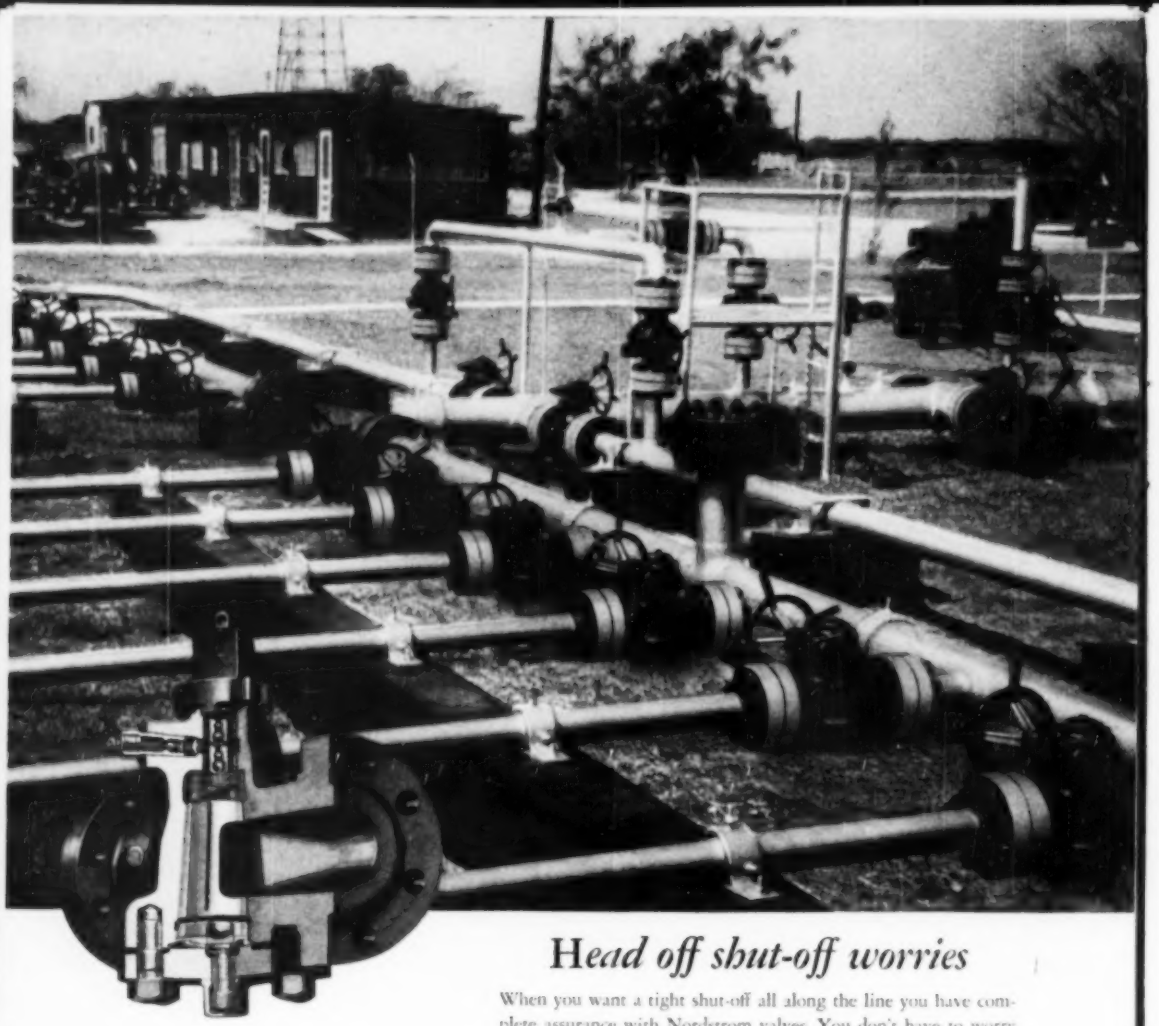
REMOTE CONTROL
made simple, safe and sure



Promoting increased efficiency in valve operation

Panelboard operation of distant valves is becoming more and more an essential convenience and a factor of greater operating safety. One central operator can be responsible for any number of valves. There's no delay in going from valve to valve, some of which may be located at great distance. Emergency shut-offs and frequent routine operation can be instantly made with Nordstrom cylinder operated valves. Their lubricated plug and simple, quarter-turn make them best adaptable to cylinder operation. Can be operated with air, gas, oil or water. In many cases, fluid in the main piping system may be used as the operating medium. Automatic shut-off for river crossings and main transmission lines is provided. Cylinder operating pressures range from 50 to 200 lb. When planning future installations, give consideration to panelboard control for increased efficiency and saving in man-hours. Nordstroms identify well-engineered plants.

Nordstrom LUBRICATED VALVES



NORDSTROMS IDENTIFY WELL-ENGINEERED PLANTS

•

KEEP UPKEEP DOWN

Use only genuine Nordcoseal lubricants

Head off shut-off worries

When you want a tight shut-off all along the line you have complete assurance with Nordstrom valves. You don't have to worry about dust, abrasives or suspensions in the line fluid interfering with valve closure. The Nordstrom rotary plug, sliding on its protected lubricant seat, closes sleeve-like instead of depending upon an imposed thrust against an exposed seat. Pressurized "Sealdport" lubrication surrounding each port prevents leakage internally and externally. This is valve engineering at its best; valve operation so positive, so sure, that no other means of line control can equal it.

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Sealdport Lubrication

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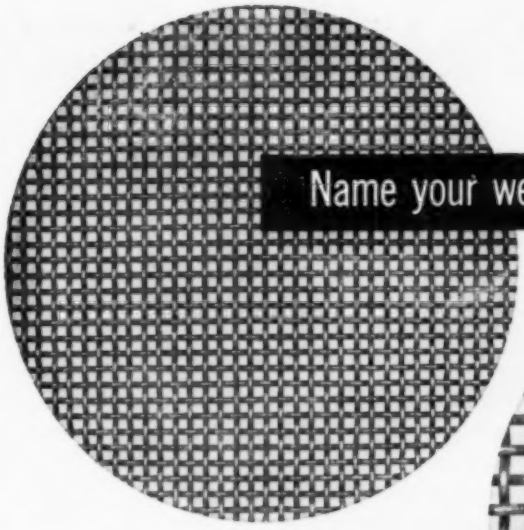

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We can help you cut wire cloth costs

With manufacturing facilities on both the East and West Coasts, and engineering sales service in key cities throughout the nation, we can help you find the answers to your wire cloth problems.

Backed by 90 years' experience, our service to over 100 industries covers the precision fabrication of wire cloth in a dozen different coarse and fine weaves; in all commonly used metals; to withstand chemical action, corrosion, abrasion, moisture, or high temperature.

Whether you use wire cloth for screening, filtering, grading, cleaning, or processing, you'll find Wissco and Calwico Wire Cloth will give long, dependable service.

Super-Tempered PRECISION SCREENS

Even under excessive vibration these screens won't wear loose in service. They're made of tough, super-tempered steel and woven on new modern power looms. Wissco and Calwico Super-Tempered Precision Screens stay tight and accurate throughout a long life. Any length required for vibrating screen or trommel can be furnished with welded, hooked, or reinforced edge to fit any type of vibrator. Write for details.

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East of the Rockies it's WISSCO
WICKWIRE SPENCER STEEL
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CF&I

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THE CALIFORNIA WIRE CLOTH CORP.
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Cosden Petroleum Corporation
Esso Standard Oil Company
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The Frontier Refining Co.
Gulf Oil Corporation
Humble Oil & Refining Company
Imperial Oil Limited
McColl-Frontenac Oil Company Ltd.
Midwest Refineries, Inc.
Mohawk Petroleum Corporation
North Star Oil Limited
Northwestern Refining Co.
The Ohio Oil Co.
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Sun Oil Company
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Welin Davit and Boat Division of Continental Copper & Steel Industries, Inc.
The Whitlock Manufacturing Co.
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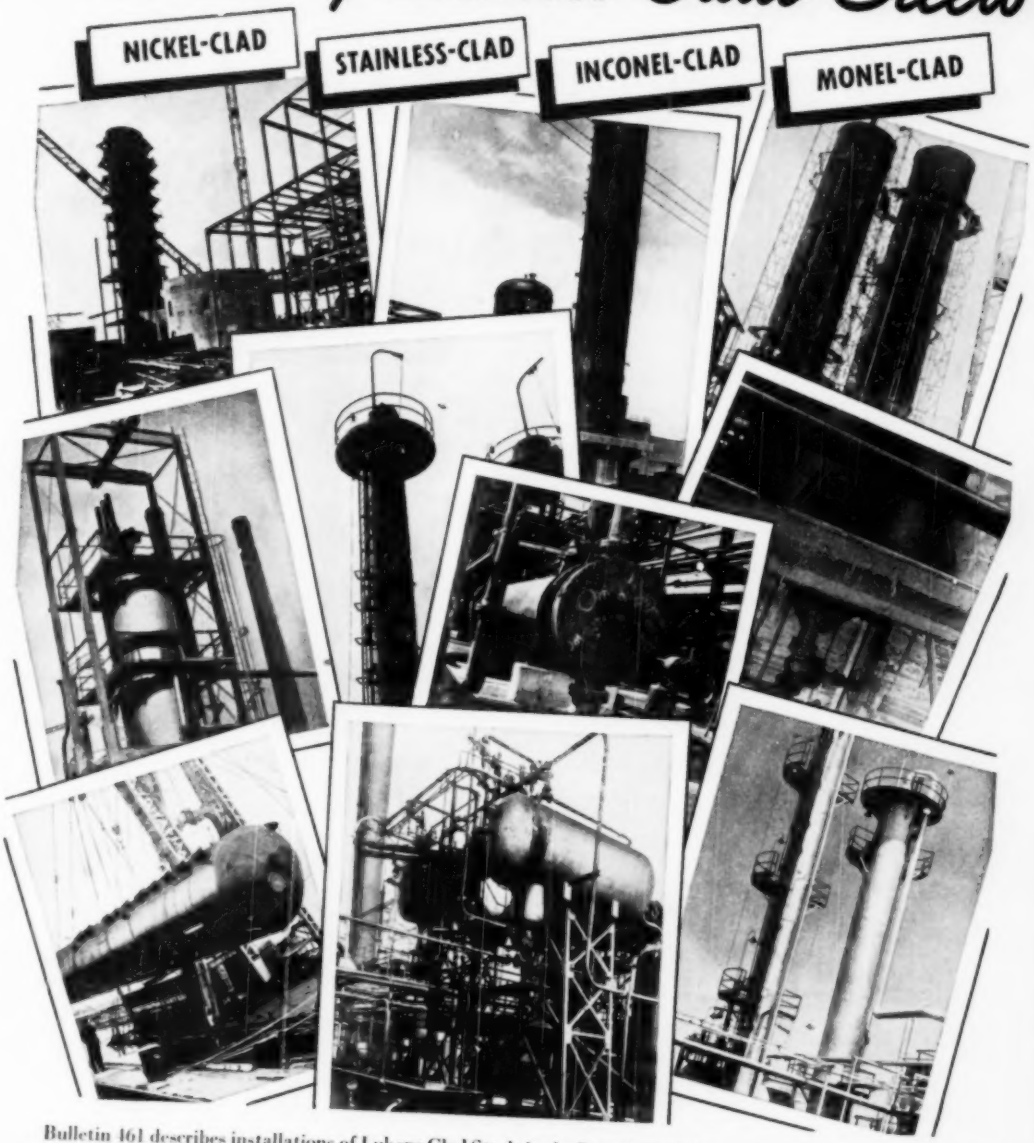
SOLID METAL ADVANTAGES

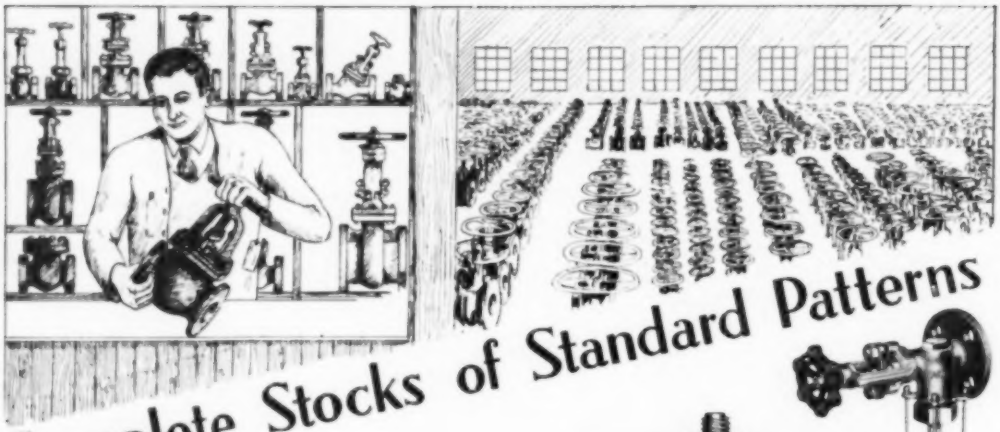
All using Lukens Clad Steels



Bulletin 161 describes installations of Lukens Clad Steels in the Petroleum Industry. For a copy and for help in adapting these corrosion-resistant metals to your equipment, write Lukens Steel Company, 400 Lukens Bldg., Coatesville, Pa.

WITH CLAD STEEL ECONOMY

LUKENS
Nickel-Clad Stainless-Clad
Inconel-Clad Monel-Clad
STEELS



Complete Stocks of Standard Patterns

Powell presents a Complete Line of Standard Valves—in Bronze, Iron, Steel, Pure Metals and Special Alloys.* These are of every type and size, and for all pressures and temperatures encountered in the many services for which they are adapted.

But ever-changing methods and processes continually impose new flow control conditions. For these Special Services, Powell Engineers are always ready with Special Designs.

The result is that Powell—and only Powell—makes such a complete line that today there's a Powell Valve specifically adapted to each and every flow control service known to Industry.

Write for information on applications of Powell Valves. And if you have any flow control problems, Powell Engineers will help you solve them.

Fig. 1891 — Flanged end O.S. & Y. Liquid Level Gauge. Offset pattern.

Fig. 1832—200-pound Stainless Steel Gate Valve with screwed ends, screwed-in bonnet and inside screw rising stem.

Fig. 2433—150-pound Stainless Steel Swing Check Valve with flanged ends and bolted flanged cap.

Fig. 2453-G—Large 150-pound Stainless Steel Gate Valve with bolted flanged yoke-bonnet, outside screw rising stem and tapered solid wedge. Made in sizes 5" to 30", inclusive.

*** Powell Valves for Corrosion Resistance are made in the widest range of metals and alloys ever used in making valves.**

POWELL

+ Special Designs for Special Services = the POWELL LINE

Fig. 3003 S. S.—Class 300-pound Stainless Steel Gate Valve with outside screw rising stem, bolted flanged yoke and tapered solid wedge.

Flush Bottom Tank Valve. Made with disc rising into tank to open valve (**Fig. 2309**) and with disc lowering into valve (**Fig. 2310**).

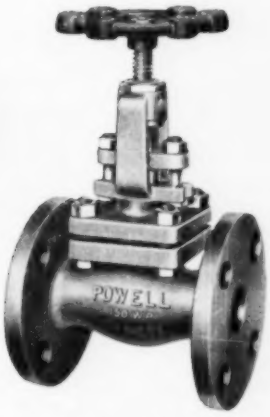


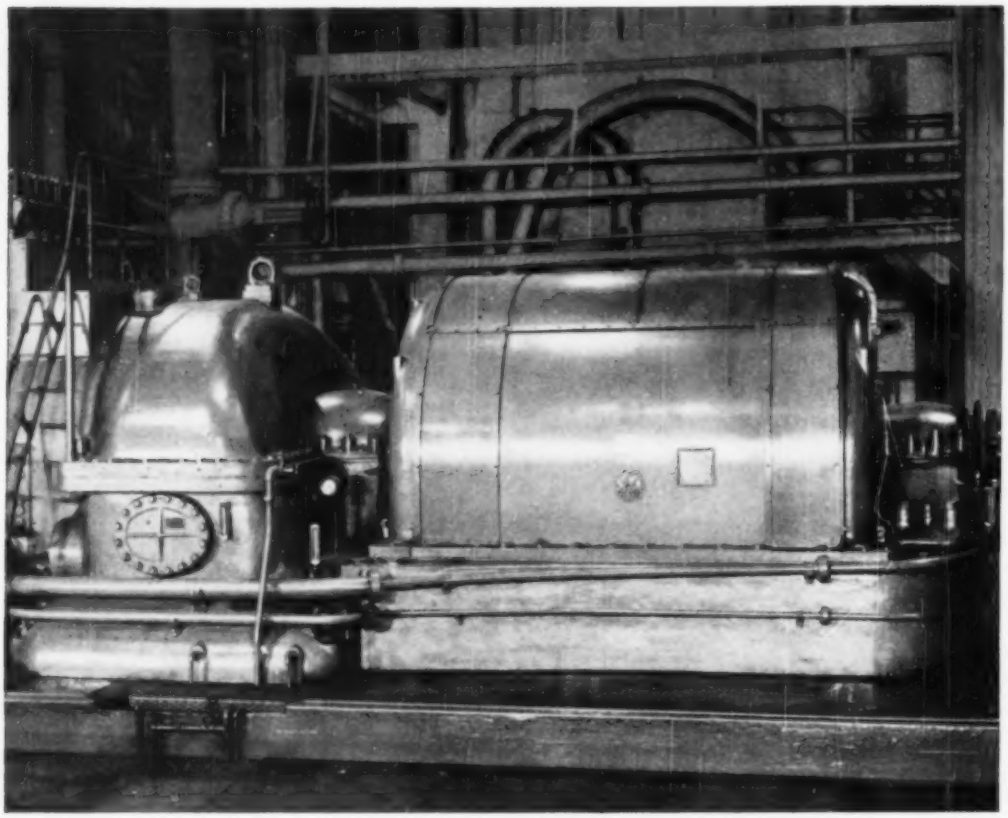
Fig. 1979—150-pound Stainless Steel Globe Valve with flanged ends, bolted flanged yoke-bonnet and outside screw stem.

The Wm. Powell Company, Cincinnati 22, Ohio

DISTRIBUTORS AND STOCKS IN ALL PRINCIPAL CITIES

VALVES

In the life-lines of this power plant...



...FIRE will meet with SUDDEN DEATH!

Fire will never get a chance to knock the generators out of commission in *this* power plant!

Two generators—rated at 12,500 and 7,500 KW—form the heart of the power supply equipment—and *both* are protected by a *single* bank of *Kidde* cylinders of carbon dioxide (CO_2). In case of fire in either generator, automatic directional valves send the CO_2 racing to the unit threatened.

First, a heavy discharge of CO_2 smothers any active flame in a matter of seconds—before damage to the insulation can spread. Then . . . a slower, continuing discharge maintains a high CO_2 concentration . . . *prevents a reflash*. Of course, the CO_2 does not corrode metal or harm insulation.

That's just one of the thousands of *Kidde** installations that are safeguarding equipment and materials all over the world. *Whatever* your fire protection problem, a Kidde representative will help you!

When you think of CO_2, call Kidde!

*Also known as "LUX"

The words "Kidde" and "Lux" and the Kidde seal are trade-marks of Walter Kidde & Company, Inc.

Walter Kidde & Company, Inc. • 528 Main Street, Belleville 9, New Jersey

Kidde

Nickel shipping drums have these 5 advantages

Drums manufactured by Niles Steel Products Division Republic Steel Corp., Niles, Ohio

1 I.C.C. ACCEPTANCE

Built to I.C.C. Specification 5K, the nickel shipping drum pictured here is used for safe, efficient handling and shipping of phosphorus oxychloride and phosphorus trichloride.

2 LIGHT WEIGHT

Tare weight of an average 55-gallon nickel drum is less than 125 pounds. Nickel drums are not only easier to handle, but they also enable you to save on freight charges.

3 CORROSION RESISTANCE

Nickel's high resistance to corrosion keeps metal pick-up low, and helps maintain product purity. That's why Nickel is so widely used in the production, handling and transportation of phosphorus compounds, caustic soda, caustic potash, phenol and other chemicals.

4 STRENGTH AND WORKING QUALITIES

In addition to corrosion resistance, nickel possesses great mechanical strength and toughness. However, this does not mean that it is hard to fabricate. Nickel is readily bent, forged and machined. It may be welded, brazed and soldered by commonly used methods.

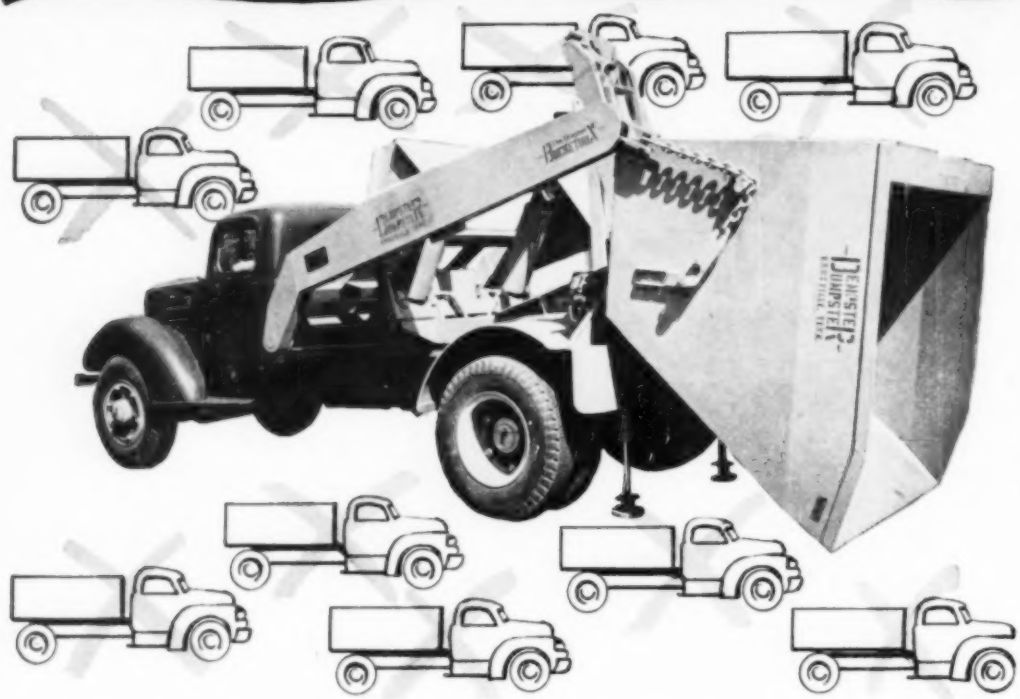
5 LONG LIFE

One company reports using the same nickel drums for handling phosphorus compounds since 1937. This is not unusual, for Nickel's unique combination of strength, toughness, corrosion resistance, hardness and ductility assures long equipment life . . . and minimum maintenance expense.

EMBLEM OF SERVICE INCO TRADE MARK *Nickel*

THE INTERNATIONAL NICKEL COMPANY, INC.
67 Wall Street, New York 5, N. Y.

One Dempster-Dumpster with 99



Being a large operation, this copper smelter required ten trucks and their crews, a series of push cars, a train car system and loading crews to handle over twenty different kinds of materials on relatively short hauls between plant buildings and outside of the grounds. The materials handled included, scrap of all descriptions, trash, rubbish, new and used brick, excavation spoil, waste oils, filter cake, dust, sand, gravel, cement, fire clay and many others.

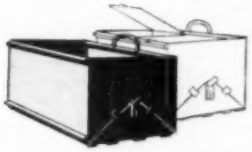
A large majority of the handling, re-handling, storage, truck and car equipment and crews standing idle, was eliminated by the Dempster-Dumpster System. Simply stated, this system provides quick pick-up of pre-loaded containers for hauling, dumping or moving material to another location. The three pictures below show how it operates. The left illustration shows the Dempster-Dumpster truck hoisting unit approaching a loaded container. Two chains are attached and the driver returns to controls in the cab. In the center photo, loaded container is hydraulically raised into carrying position. Controls in the cab permit dumping as illustrated at right. You too, may be able to adapt the Dempster-Dumpster System of Materials Handling to your business at tremendous savings. Let one of our engineers discuss this possibility with you.

Containers replaces 9 trucks....

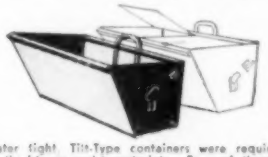
Over $50,000 saved annually . . . in this Copper Plant through faster, more efficient, materials handling

Here, in plain language, is what happened to Materials Handling costs after the Dempster-Dumpster System of Materials Handling was installed in a large Western copper smelting plant. A comprehensive Dempster-Dumpster survey had previously revealed costly delays, unnecessary handling and rehandling of materials, and much time wasted by loading crews. All have been eliminated to the tune of $50,000 savings annually. Fast pick-up, hauling and dumping of pre-loaded Dempster-Dumpster containers has replaced the old method of plant hauling. As a result, nine of the ten trucks formerly detailed for this work were eliminated or put on other work. Ninety-nine detachable containers, built in over 20 sizes and designs for the specific materials they were to handle, were spotted at material accumulation points throughout the plant. Some containers, provided with roller bearing casters, are rolled to indoor accumulation points. Some are handled by fork trucks, other by overhead cranes within plant buildings. As containers are filled, the Dempster-Dumpster truck hoisting unit and one man, the driver, picks each container up, hauls it to its destination, dumps it and returns the empty container for refilling or, loaded container is lowered at any point and left if desired. When you consider that pick-up and dumping of these detachable containers takes less than 60 seconds, and that the entire operation works to an on-the-run schedule, you will realize how one truck hoisting unit can handle 99 containers and do the work formerly requiring ten conventional trucks.

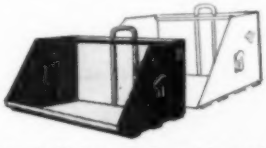
In the panel below are shown the basic types of Dempster-Dumpster Containers used in this installation. The basic containers can be altered with lids, casters, hose and chute connections, etc., to handle accumulations of any type material whether it be liquid, solid, dust, gas, light or heavy materials.



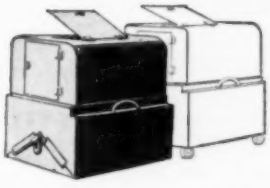
Forty-nine open top, drop-bottom containers in 3, 4, 8 and 10 cu. yd. capacities were spotted at 38 locations throughout the smelter operation. Four of these were 10 cu. yd. containers fitted with two end doors and a circular top opening for chute loading. Three of the 34—4 cu. yd. drop-bottom containers in this group were equipped with self balancing spring lids for special use.



Ten water tight, Tilt-Type containers were required to handle liquids or moist materials. Four of these were open top of 1½, 3 and 4 cu. yd. capacities for four locations. One 4 cu. yd. container with self balancing spring lids was provided at Lab Sample Mill. Three containers, with self balancing lids provided with pipe inlets, were supplied for receiving waste oil at three separate locations. Two 3 cu. yd. containers having three separate compartments with individual lids for each compartment, were required for the zinc electrolytic plant.



Two 4 cu. yd. skip-type, with lip, containers and two 4 cu. yd. skip-type, flat-bottom, containers were spotted at two locations. One 6 cu. yd. flat-bottom, skip-type container was furnished.



Thirty-three Universal-type containers in 6 and 10 cu. yd. capacities were spotted at 33 locations to receive trash, rubbish and other bulky materials. Two of these were mounted on roller bearing casters for movement to indoor loading locations.

Two 10 cu. yd. Apartment-type containers were spotted at the main office and laboratory office to receive large accumulations of waste paper and trash.

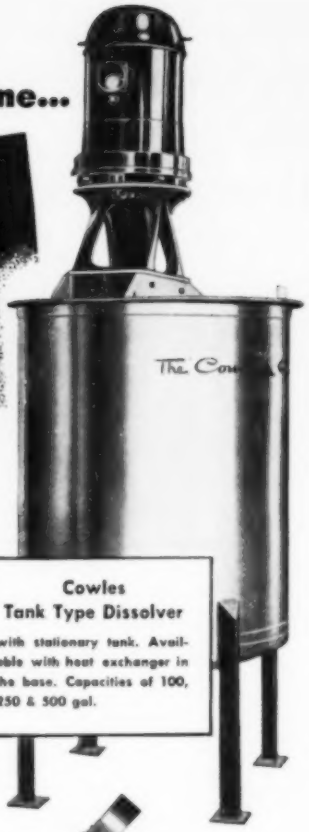
DEMPSTER DUMPSTER
TRADE MARK REG.
SYSTEM

DEMPSTER BROTHERS, Inc., 259 Dempster Bldg., Knoxville 17, Tenn.

Ask the Man who has Bought More Than One...

Cowles ULTRA-FAST DISSOLVER

He'll tell you that the Cowles method is 2 to 20 times FASTER on tough dissolving and dispersing jobs.



Cowles Tank Type Dissolver

with stationary tank. Available with heat exchanger in the base. Capacities of 100, 250 & 500 gal.

Yes—35% of our recent sales have gone to companies that have bought again and again. Companies that had tried, owned and operated Cowles Ultra-Fast Dissolvers in their own plants . . . on their own materials . . . with their own operators. And they were so pleased that they came back for more machines—some even re-replacing newly-installed equipment with Cowles Dissolvers.

Let us demonstrate on YOUR materials

Below is a record of comparative operating times on standard commercial processes. In every case the Cowles Dissolver consistently outperforms other types, saving in some instances up to 46½ hours. Such a wide difference in operating times challenges belief, we know. So don't just accept these figures; let us show you what the Cowles Ultra-Fast Dissolver can do on *your* materials. There's no cost, no obligation. Just write or wire . . .

Engineered to the job

Standard dissolvers employing the Cowles Method are available in 4 different types, each specially adapted in motor speed, horsepower, impeller and chemical inertness of tank to the physical and chemical properties of the materials being treated. But special designs to fit special processes are regularly produced under reasonable delivery-date schedules. Let our engineers study your needs and make a recommendation. You may find your problem simpler than you think.

Cowles Model SVT Tilted

Cowles Model 20D-2

Impeller elevates 54" and swings in an 180° arc for line processing in containers brought to the machine.

Cowles Model 10D-1

(not illustrated)

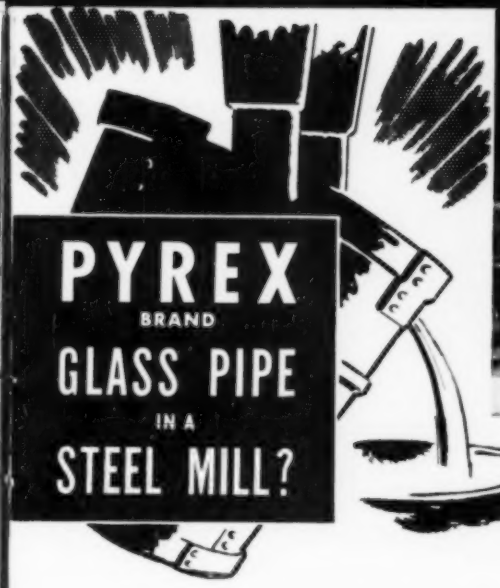
Impeller elevates 38" and swings in a 90° arc. Will process from 5 to 200 gallons per batch, depending upon characteristics of materials used.

7 YEARS OF COMMERCIAL TEST SHOW COWLES DISSOLVER UP TO 46½ HOURS FASTER ON TYPICAL OPERATIONS

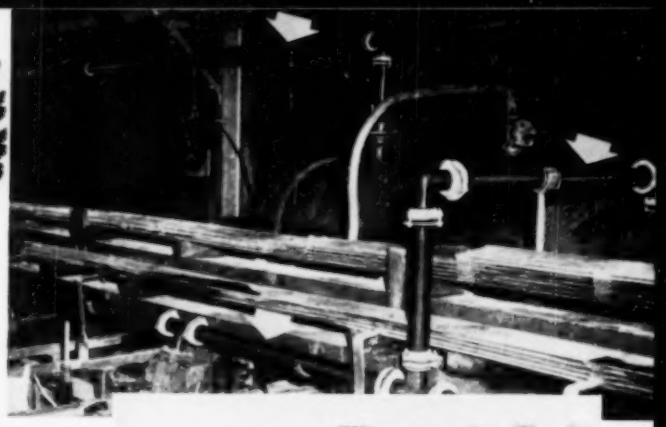
Type Operation	Material	Cowles Dissolver	Standard Mixer
Gum Cutting	Rosin	1½ Hrs.	12 Hrs.
Synthetic resin dissolving	Vinylite	1 Hr.	6 Hrs.
N/C solution	Nitrocellulose	12 Min.	90 Min.
Washing	Scrap Film	1½ Hrs.	48 Hrs.
Pigment dispersion	Heavy Enamel	6 Min.	130 Min.
Coating suspension	H. T. Clay	1 Hr.	9 Hrs.

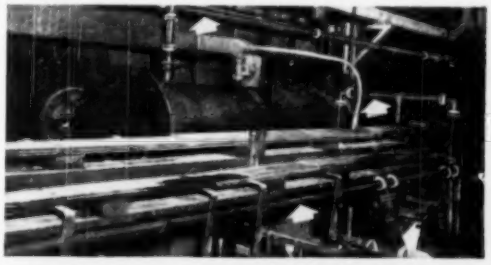
The Cowles Company
INCORPORATED
15 Trackside, Cuyuga, N. Y.

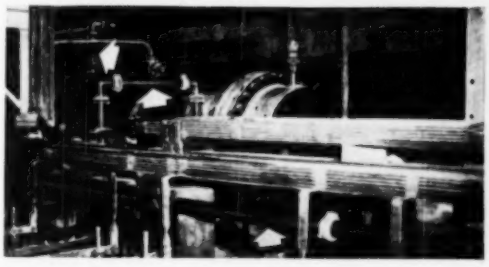
Associate: Alexander Flock, Ltd., Ottawa, Ont.



PYREX BRAND GLASS PIPE IN A STEEL MILL?







Although not too "photogenic" these installation pictures show how PYREX brand glass pipe is used at the Thomas Steel Company, Warren, Ohio, for conveying *electroplating* solutions throughout the mill. Note that this pipe is used right along with other materials of construction.

Corrosion recognizes no barriers. Acid is acid wherever you find it. That's why PYREX brand glass pipe is working in a steel mill!

Replacement of acid corroded pipe lines cost too much at the Thomas Steel Company. How about PYREX pipe, would it stand up under the conditions involved? Corning engineers entered the picture. They recommended an installation.

Now PYREX pipe snakes its way throughout the mill. Its high chemical stability plus its resistance to physical and thermal shock makes PYREX pipe practical even in a steel mill.

This is only one of many installations which illustrates the practical advantages of PYREX brand glass pipe. An interesting booklet describing such installations and the advantages users see in PYREX pipe is available for the asking. Write Corning or use coupon below for Bulletin EA-1.

PROMPT DELIVERY... Corning's increased production facilities make it possible to give you prompt, "off the rack" delivery of PYREX brand glass pipe. Balanced stocks are maintained of all standard sizes—1", 1½", 2", 3" and 4" O.D.; also fittings such as elbows, tees, crosses, return bends, reducers, etc.

CORNING GLASS

PYREX

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TECHNICAL PRODUCTS DIVISION: GLASS PIPE • SIGNALWARE • LABORATORY GLASSWARE • GAUGE GLASSES • LIGHTINGWARE • OPTICAL GLASS • GLASS COMPONENTS

CORNING GLASS WORKS
Dept. CE-5 Corning, N.Y.

Please send me your new Bulletin EA-1 "PYREX" brand Glass Pipe in the Process Industries."

NAME_____ TITLE_____

COMPANY_____

ADDRESS_____

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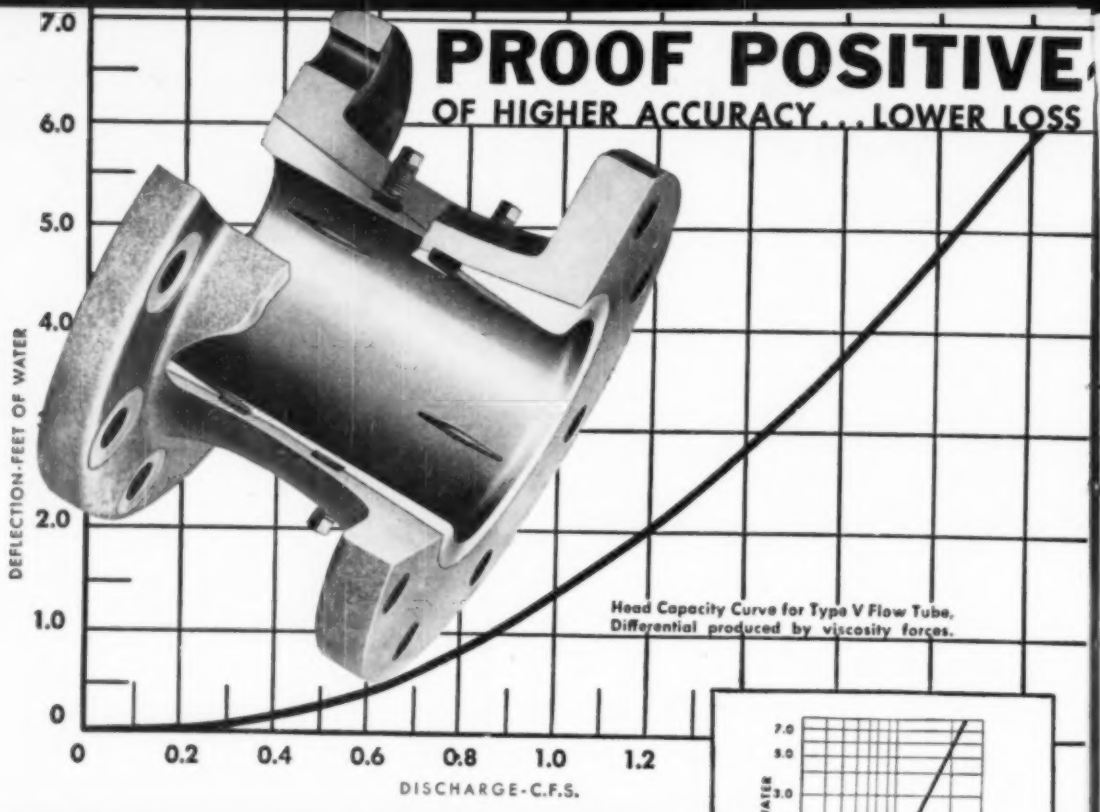
PROOF POSITIVE

OF HIGHER ACCURACY . . . LOWER LOSS



Head Capacity Curve for Type V Flow Tube. Differential produced by viscosity forces.

NEW BETHLEHEM FLOW TUBE*

PROVES CONSTANT COEFFICIENT OVER 8:1 RANGE OF DISCHARGE

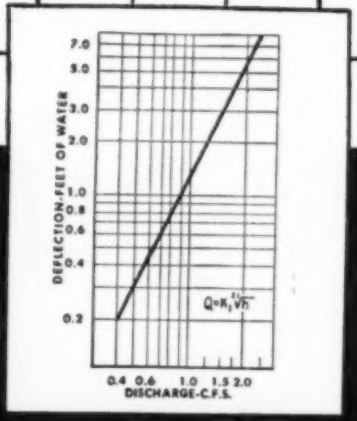
Now! The new Bethlehem Flow Tube—for large savings in power . . . higher product quality . . . large installation savings—offers proof positive of consistent accuracy.

In calibration tests conducted by an independent hydraulic laboratory—one of the foremost in the country—the Bethlehem Flow Tube held its high accuracy to the limit of the testing apparatus. Discharge plotted against head proved that differential head is in all cases proportional to a constant power of velocity . . . that discharge coefficient is constant over *an 8:1 range of discharge.*

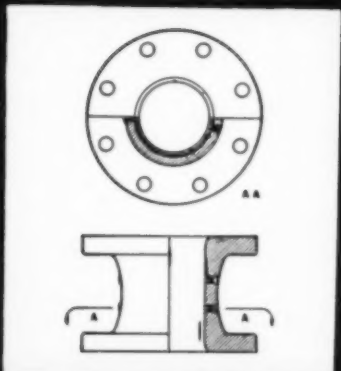
Add to this: one pipe diameter length . . . negligible resistance to flow in most installations . . . minimum straight run limitations after elbows and similar fittings . . . measurement of gases without consideration of compressibility factors and the Bethlehem Flow Tube becomes an outstanding improvement wherever it is necessary to measure or control fluid flow.

Find out the details of its revolutionary operation now! Write for the folder, "Bethlehem Flow Tube."

*GENTILE PATENTS



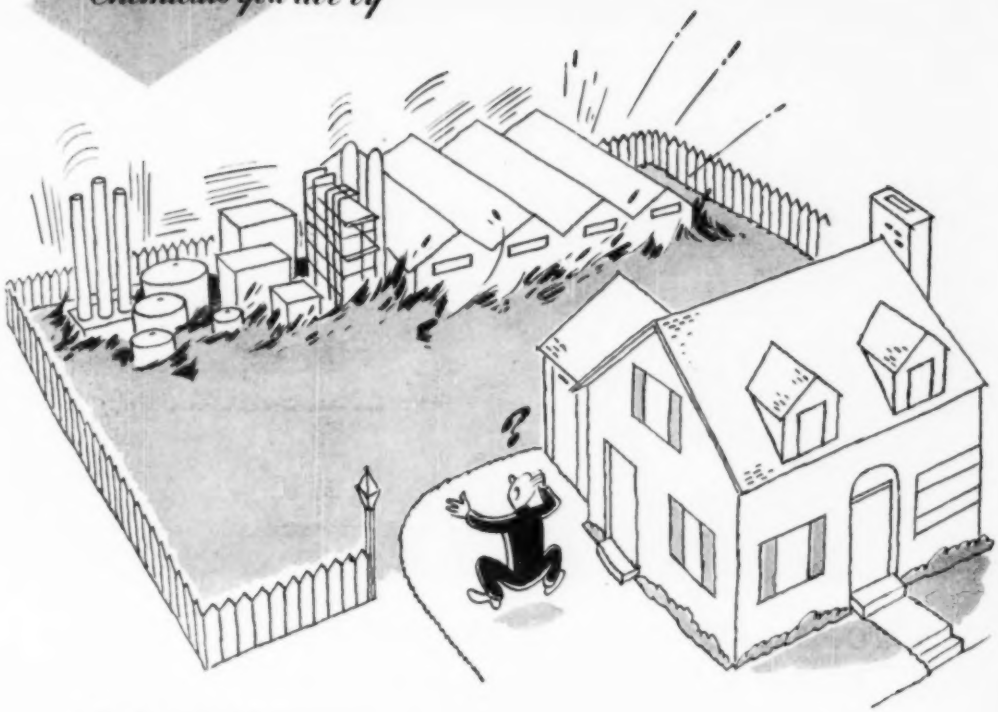
Log Plot of Head Capacity Curve.



Cross-Section of Type V Flow Tube. Pat. No. 2,260,019. Other patents pending.

BETHLEHEM FOUNDRY & MACHINE CO., BETHLEHEM, PA.

Chemicals you live by



CHEMICALS . . .
MADE IN YOUR OWN BACK YARD

Whether your plants are on the Atlantic seaboard, in the Midwest, the Southwest, or the Far West, chances are you'll find DIAMOND ALKALI making chemicals you need, right in your own back yard.

DIAMOND'S twelve chemical plants parallel closely the country's industrial development; provide both a near-by and a flexible source of supply. Chlorine and caustic soda, for example, are produced at four points located from Chesapeake Bay and Lake Erie to the Gulf Coast; silicates in six plants spread from the East to the West Coast; chromates in three plants on the East Coast and Lake Erie. Soda ash, bicarbonate of soda, calcium compounds and other "Chemicals You Live By" are produced at our ever-growing chemical center at Painesville, Ohio.

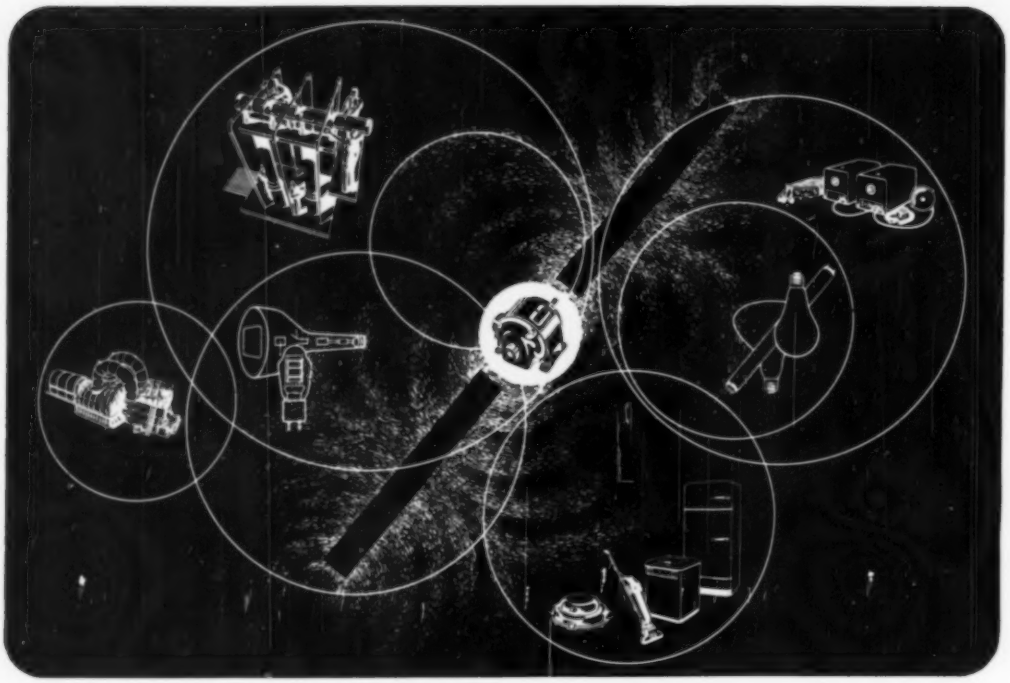
To make this supply readily available to industry now and assure "tops" in service, DIAMOND sales offices are spotted in twelve convenient cities. And rounding out this chemical setup for industry, DIAMOND'S Technical Service Division is ready to help solve your problems relating to the chemicals we produce. Just get in touch with your nearest sales office or write us direct.

DIAMOND SALES OFFICES: Boston, New York, Philadelphia, Pittsburgh, Cleveland, Cincinnati, Chicago, St. Louis, Memphis, Wichita, Oklahoma City and Houston. Also representatives in other principal cities in the United States.

DIAMOND ALKALI COMPANY • CLEVELAND 14, OHIO

DIAMOND ALKALI CHEMICALS

SODA ASH • CAUSTIC SODA • CHLORINE & DERIVATIVES • ALKALI SPECIALTIES
BICHROMATES • SILICATES • CALCIUM COMPOUNDS • BICARBONATE OF SODA



23 CONTRACTS IN 30 YEARS FROM THE GENERAL ELECTRIC COMPANY

In 1919 we started our first engineering and construction job for General Electric—and we've been working for them pretty steadily ever since. Our "G. E." jobs have ranged from warehouses to complete new plants in many different parts of the United States.

Repeat contracts from satisfied customers have always made up a major share of our business, in all of the 30 industries we have served. That's because clients like the ease and economy of working with us under one contract and one responsibility . . . whether the job is an engineering survey, a modernization project, or delivery of a complete plant fully equipped and ready for operation.

The H.K. Ferguson Co.
INDUSTRIAL ENGINEERS AND BUILDERS

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CHICAGO • 120 S. LaSalle Street • Phone Financial 6-3767
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LOS ANGELES • 712 South Curson • Phone Wyoming 9496
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Many industrialists have found it profitable to retain us on a *continuing* basis to handle *all* of their engineering and building problems as they arise. That method may have advantages for you. Why not call or write our nearest office?

UNDER ONE CONTRACT AND ONE RESPONSIBILITY, WE DESIGN, BUILD, AND EQUIP OUTSTANDING ANTIBIOTIC LABORATORIES • RESEARCH LABORATORIES FOOD PROCESSING PLANTS • RAYON PLANTS • PAPER MILLS • ATOMIC ENERGY PLANTS • CHEMICAL PROCESS PLANTS OF ALL KINDS • INDUSTRIAL PLANTS POWER PLANTS • WE ALSO FURNISH ENGINEERING REPORTS AND SURVEYS

YOU USE 4 + 8

YOU GET 100,000

That's all it takes! Four basic circuits and 8 basic component parts give you more than 100,000 different electronic instrument combinations for processing use.

Flow, level, speed, pressure, temperature, gas analysis, pH, conductivity, etc.—all can be controlled with these interchangeable Bailey units.

With Bailey controls, replacement part stocks are held to a minimum because parts are interchangeable. Maintenance costs are less, too, because maintenance men quickly become familiar with the standardized Bailey units.

Bailey bulletin No. 17 shows how you can use this improved control system. Write for your copy and keep it handy for reference the next time you need process controls.

P-19

BAILEY METER CO.

1054 Ivanhoe Rd. • Cleveland 10, Ohio

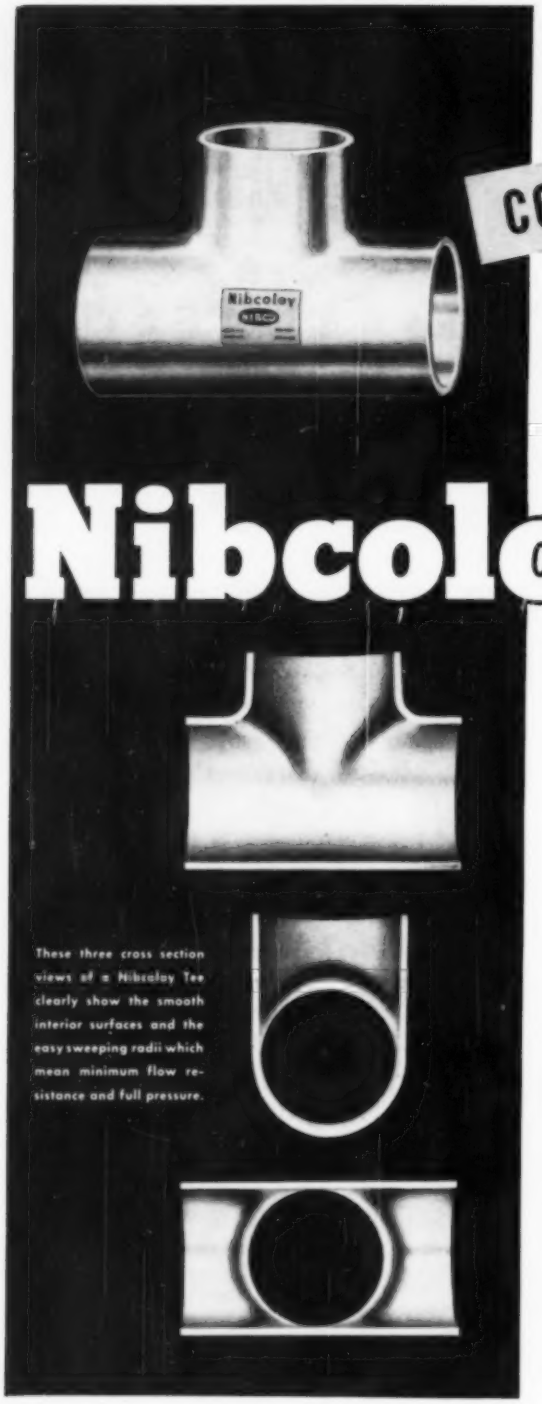
BAILEY METER CO. LIMITED, MONTREAL

Controls for the Chemical Industry

TEMPERATURE • FLOW • PRESSURE

GAS ANALYSIS • LEVEL • RATIO

4 + 8 Works Here at the Wyandotte Chemicals Corporation North Plant, Wyandotte, Michigan



These three cross section views of a Nibcoloy Tee clearly show the smooth interior surfaces and the easy sweeping radii which mean minimum flow resistance and full pressure.

COLD FORMED FROM A SINGLE TUBE

Nibcoloy WROT FITTINGS

SMOOTH INTERIORS ASSURE FREE FLOW, REDUCE TURBULENCE

Notice the easy sweeping radii and the smooth interior surfaces which keep turbulence at a minimum and assure full effective pressure through the whole piping system. Formed from the same kind of tubes with which they are used, NIBCOLOY Wrot Fittings insure full wall strength at all points and the same physical and metallurgical characteristics throughout.

No welds and no seams! All NIBCOLOY fittings — tees, elbows, couplings, return bends — are cold formed from a single tube by the same exclusive patented process. They are available from 1/4" O.D. to 4" O.D. in Monel, Inconel, Nickel and Stainless Steel 304—347—316. They make possible quality installations with economical light weight tubes, and are especially adaptable where corrosion and turbulence are problems.

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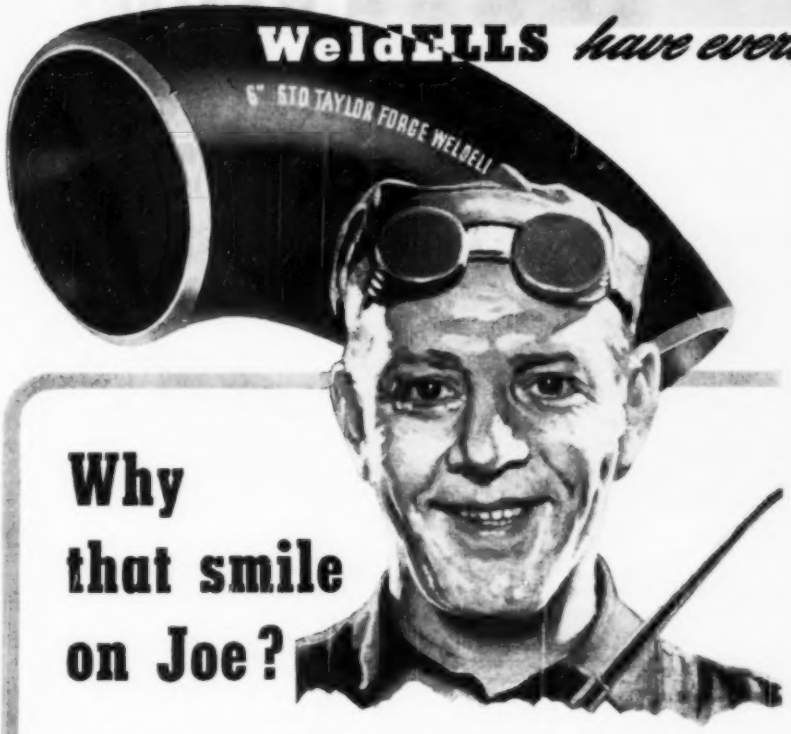

Why that smile on Joe?

Joe may not know much about the engineered strength of WeldELLS, or the metallurgical control, or the greater scope of the WeldELL line. However, it is plain enough that these considerations which mean so much to you begin to lose meaning unless Joe does *his* part of the job right.

That's why we designed WeldELLS, not only for you, but also for Joe. That's why Joe smiles: A good Welder like Joe takes extra pride in the kind of job he can turn out when it's made easy for him by these easily identified fittings, with sized end tangents, cleanly machined bevels, precision quarter markings to speed lining up, accurate key dimensions, plus other conveniences that are combined only in WeldELLS.

Yes, Joe does a better job with WeldELLS . . . and in the final analysis, *your* work rests on Joe's work!

Remember that the line which offers the most to both you and Joe, also contains the most complete range of sizes, thicknesses, and types of fittings, *and* in a complete range of materials. Convenient stocks are carried in all industrial centers.

Note these features that appeal to the man on the job:

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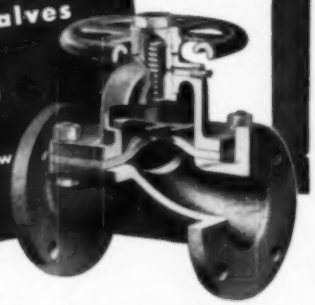

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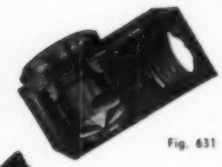

Fig. 631

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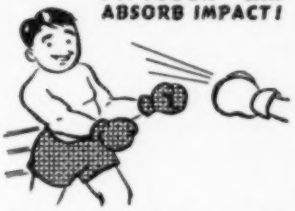

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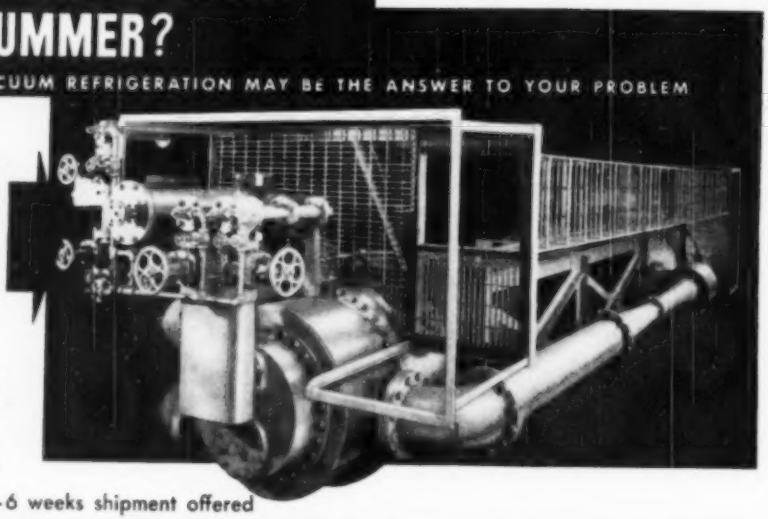

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By Way of Introduction

A columnist must choose his approach: he can gossip, comment, amuse, or inform. This is to be a column of informative comment. The subject: *Activated Carbon.*

Activated Carbon—an exceedingly useful tool of the chemical engineer—is in the realm of physical chemistry. Here's a field so broad that educators in our schools of science must hurry along, touching only briefly on many phases of the subject. A student may hear a brief mention of Activated Carbon, usually in connection with colloid phenomena. The extent to which he indulges his curiosity determines what more he will learn about the subject.

The aim of this column is to help you become more familiar with Activated Carbon: to point out, for example, some of the interesting facts about it, some of the lesser known methods of using it, and reliable ways of evaluating it. This column will appear in this publication at regular intervals—watch for it! The subject of the next column will be: "What *Is* Activated Carbon?"

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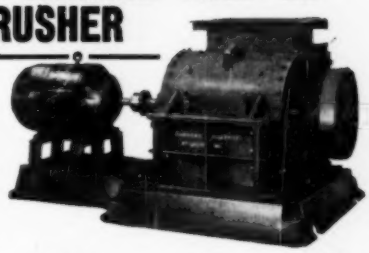

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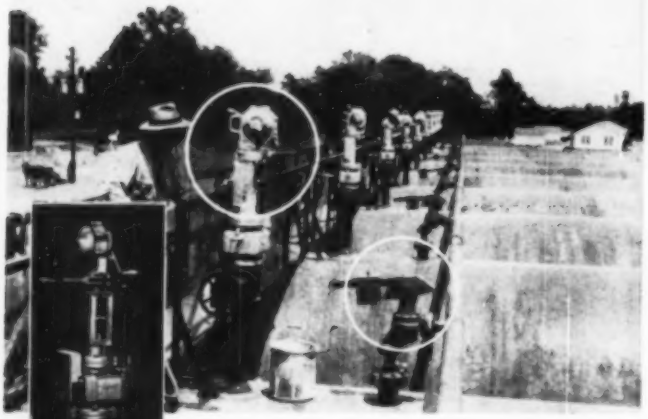

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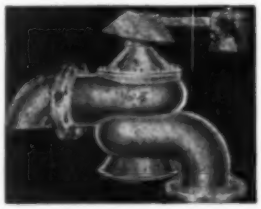

Figure No. 480 Series "VAREC" Pressure and Vacuum Relief Valve, dead weight loaded palet. Available in sizes from 2 in. to 8 in. and pressure settings to 1 lb. 8 oz. Pressure settings to 60 lbs. Available in spring-loaded pressure palet type, Figure No. 481 Series.

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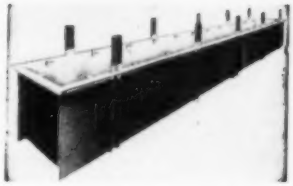

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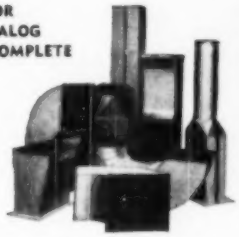

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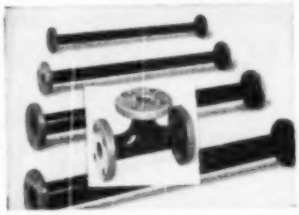

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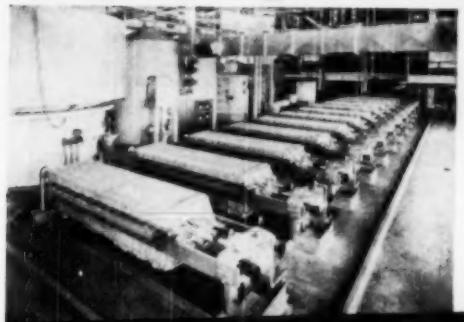

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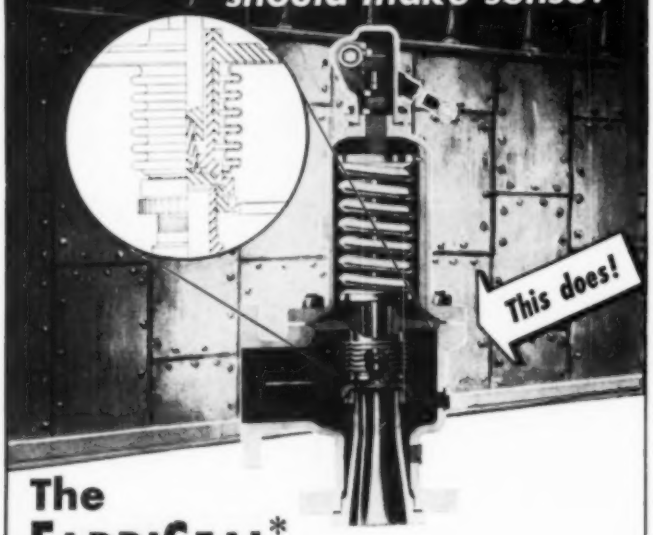

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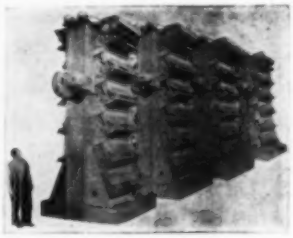

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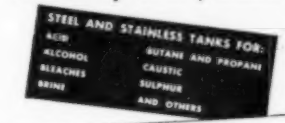

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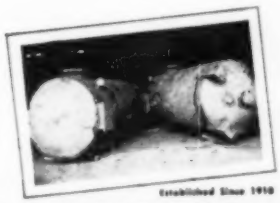

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LANCASTER, PENNA., U.S.A.
DIVISIONS: Steel Plate • Asphalt • Steel Pipe • Brick Machinery

Custom Built
STAINLESS STEEL EQUIPMENT . . . .

. . . *is* ONLY AS GOOD AS ITS FABRICATOR

From the minute you decide on a made-to-order stainless steel vessel, you're in the hands of a fabricator. In fact the selection of your fabricator is generally one of your big problems.

It's more than a question of following blueprints. Stainless steel is a difficult alloy to work. It "acts up" during fabrication. In cutting, forming, welding and even in finishing, your fabricator must know how to guard the corrosion resistance and strength of the alloy. His plant must be specially equipped for working with stainless steel. The longer his experience, the more help he'll give you in building vessels that meet your requirements.

We work exclusively with stainless steel and alloys. Our plant is specially tooled to fabricate this metal. Our engineers and mechanics are particularly trained for the work. Why not consult us when you plan your next stainless steel vessel?

S. BLICKMAN, INC. • 605 GREGORY AVENUE • WEEHAWKEN, N. J.

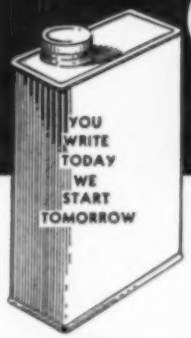
S. BLICKMAN, INC.
Guards Alloys in Fabrication

SEND FOR THIS VALUABLE BOOK
A request on your letterhead will bring our guide, "What to Look For When You Specify Stainless Steel for Your Processing Equipment."

CORROSION RESISTANT PROCESSING EQUIPMENT

TANKS • KETTLES • STILLS • HEAT EXCHANGERS • AGITATORS • MIXERS • TOWERS • PIPING

WE TURN OUT A LITHO CAN QUALITY JOB QUICKER THAN ANYONE ELSE IN THE COUNTRY



AVAILABLE IN ALL SIZES
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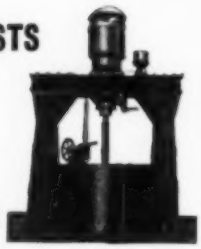
Our Reputation:
"A Good Job in the Shortest Time"
If you can't visit us and see samples,

Write! Try us! Inquire!

FOR
Automotive Chemicals, Household Chemicals, Glycerine, Lube Oils, Insecticides, Turpentine etc.

EASTERN CAN COMPANY, INC.
KeapStreet, Wythe & Kent Avenue, Brooklyn 11, N.Y.
Phone: ULster 5-0100

SLASH PRODUCTION COSTS WITH Fletcher CENTRIFUGALS



SPEEDY • SAFE • STABLE • STURDY

The wide acceptance of Fletcher Centrifugals by leading chemical engineers everywhere is no accident. These machines are the result of many years research into the problems of chemical separation and filtering. Precision in manufacture and skill in design of Fletcher Centrifugals have provided features which mean greater production at minimum cost.

- The "Centroid" speed control . . . provides 3 speeds, one for efficient loading, one for spinning and another for easy unloading.
- The Fletcher has the largest capacity in proportion to basket diameter.
- Unbalanced loads are handled easily.
- For greater convenience, Fletcher provides large bottom discharge for solids.
- The Fletcher offers faster acceleration . . . faster, safe braking.

Write for further information today.
MOTOR DRIVEN SUSPENDED AND OPEN TOP

FLETCHER CENTRIFUGALS
FLETCHER WORKS, 235 GLENWOOD AVE., PHILADELPHIA 40, PA.

are you sure that you need plant expansion?

Many a manufacturer has discovered, to his surprise and profit, that his present plant needs *re-design* — not expensive expansion. Efficient use of space can sometimes *double* production potential.

BE SURE—BEFORE YOU BUILD

Ask yourself these questions:

1. Do I really need expansion?
2. Is my present production system the most efficient?
3. Will my new layout permit further expansion?
4. If I must build, should I locate elsewhere?

EBASCO can provide the answers

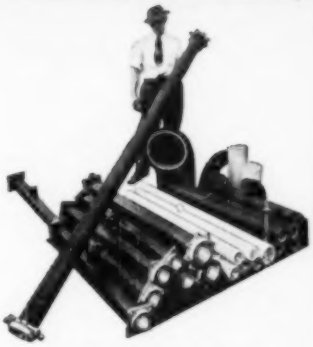
In EBASCO you have a single organization equipped with the specialists and experience to answer these questions...to re-design your present plant, or build a new one if you need it. We can equip it and put it into production. What's more, we'll do any part — or the whole job — even stay on to assist in training your help to run your plant.
For details about this team of several hundred engineers and business consultants, write for our booklet THE INSIDE STORY OF OUTSIDE HELP. We'll send it to you promptly.

EBASCO SERVICES INCORPORATED
Two Rector Street
New York 6, N. Y.

ENGINEERS · CONSTRUCTORS · EBASCO · BUSINESS CONSULTANTS

Appraisal · Budget · Business Studies · Consulting Engineering
Design & Construction · Financial · Industrial Relations
Inspection & Expediting · Insurance & Pensions
Purchasing · Rates & Pricing · Research · Sales & Marketing
Systems & Methods · Taxes · Traffic

PYROSIL



Armored
FUSED QUARTZ PIPE
Has Remarkable Properties!

Pyrosil Armored Pipe consists of fused quartz tubing reinforced with Fiberglas-laminated furane plastics. Thus, the inertness of fused quartz is combined with the toughness of laminated plastics.

It is:

—Proof against extreme thermal shock.

—Not resistant but totally inert to all combinations of acids up to 375° F. (except HF).

—Strong, shatterproof, suitable for working pressures of 100 lbs. per sq. in. and above inasmuch as the bursting pressure is a function of the laminated plastic sheathing.

—Light weight, simple to install, joints flanged or wrapped.

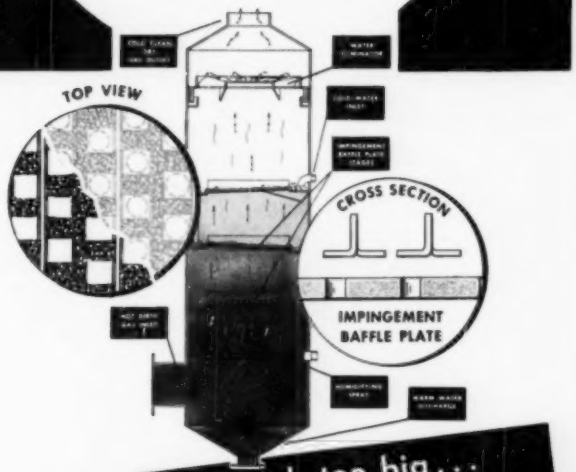
—Available now in 1 to 12 in. sizes, 10 ft. spans and all fittings.

Write for bulletin No. 10 which gives complete design and engineering data.

PYROSIL, Inc.
Cuyahoga Falls Ohio

Also available in practical piping systems for continuous service to 2,000°F

We welcome your gas *cleaning* and *cooling* problems



no job too big . . . no job too small

Peabody Scrubbers, Coolers and Absorbers utilize *Impingement Baffle Plates* to direct a multiplicity of small gas streams against wetted individual baffles located above each gas jet. Intimate contact between gas and liquid results from this scrubbing action and high efficiencies are achieved in eliminating suspended material from gases and in heat transfer, as well as in absorption processes.

Peabody equipment is serving many types of process plants operated by prominent companies throughout the United States and abroad. Typical gases handled by Peabody Scrubbers include those from rotary and shaft kilns, reaction vessels and combustion chambers.

The experience gained from a wide variety of installations is at your service; an inquiry will receive prompt attention.

298-4

Write for Bulletin H-203-C

PEABODY
ENGINEERING CORPORATION
580 FIFTH AVENUE • NEW YORK 19, N. Y.
Offices in Principal Cities

If You Are Having Difficulty Maintaining Your Mailing Lists...

Probably no other organization is as well equipped as McGraw-Hill to solve the complicated problem of list maintenance during this period of unparalleled change in industrial personnel.

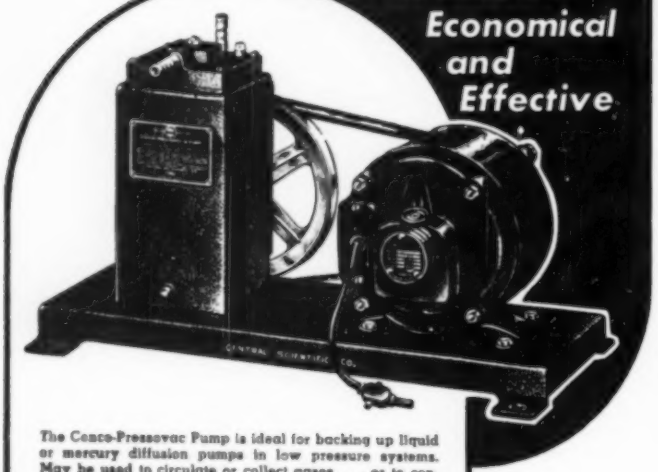
McGraw-Hill Mailing Lists cover most major industries. They are compiled from exclusive sources, and are based on hundreds of thousands of mail questionnaires and the reports of a nation-wide field staff. All names are guaranteed accurate within 2%.

When planning your direct mail advertising and sales promotion, consider this unique and economical service in relation to your product. Details on request.

McGraw-Hill Publishing Co., Inc.
DIRECT MAIL DIVISION
330 West 42nd Street New York, 18, New York

for PRESSURE or VACUUM

Economical and Effective



The Cenco-Pressovac Pump is ideal for backing up liquid or mercury diffusion pumps in low pressure systems. May be used to circulate or collect gases . . . or to conduct fumes from distillations to vents. It has large free air displacement . . . 34 liters per minute. Guaranteed to attain 25 microns pressure. When compressed air is required, this pump will satisfy the need . . . 10 lbs. per square inch, maximum. Designed for trouble-free operation and long service.

Price, each $75.00

Write Dept. BJ for Engineering Bulletin 10.

No. 98510A Cenco-Pressovac Pump for 115 volts, 60 cycle, A.C. Models are available for other voltages, frequencies, and direct current.

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Scientific Apparatus · Instruments · Chemicals
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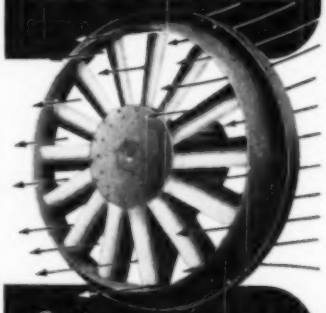
efficiency plus



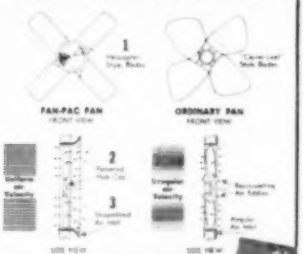
Only DeBOTHEZAT AXIAL-FLOW VENT SETS *have all 3*

1 HELICOPTER-TYPE FAN BLADES
Greater Efficiency! Provides quiet, uniform air velocity from hub to blade tip. Non-overload power characteristic prevents motor burn-out.

2 PATENTED HUB CAP--
Prevents Recirculation at Fan Hub! Eliminates re-entry of exhausted air at hub, making it unnecessary to re-discharge air once moved.

3 STREAMLINED AIR INLET --
Up to 16% More Efficient Than Ordinary Inlets! Logarithmic entrance ring eliminates sharp bends in the air stream. Full use of fan blade tip velocity is achieved.

CONCLUSIVE PROOF BASED UPON ACTUAL WIND TUNNEL TESTS!



SEND FOR FREE CATALOG!

DEBOTHEZAT FANS, Dept. C-5
Division of American Machine and Metals, Inc.
EAST MOLINE, ILLINOIS
Without obligation, send new illustrated Catalog and data on Axial-Flow Vent Sets.

FIRM NAME _____
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Increase the life of your Cotton Filter Cloths

by impregnation with

THŌRATEX

REG. U. S. PAT. OFF.

—resists corrosive action of Alkaline and Caustic solutions

—mildew and rot resistant

—frequently outlasts untreated fabrics three to one

OTHER ADVANTAGES:

- Maintains filtering capacity
- Smooth surface
- Cakes come away easily
- Reduces gumming
- Fewer washings required
- More continuous press operation
- Less shrinkage on press
- May be used in cold or boiling filtrations
- May be used with hydro-carbon solvents
- Non-capillary
- Better filtration
- Soft, flexible—sews easily

FREE TRIAL

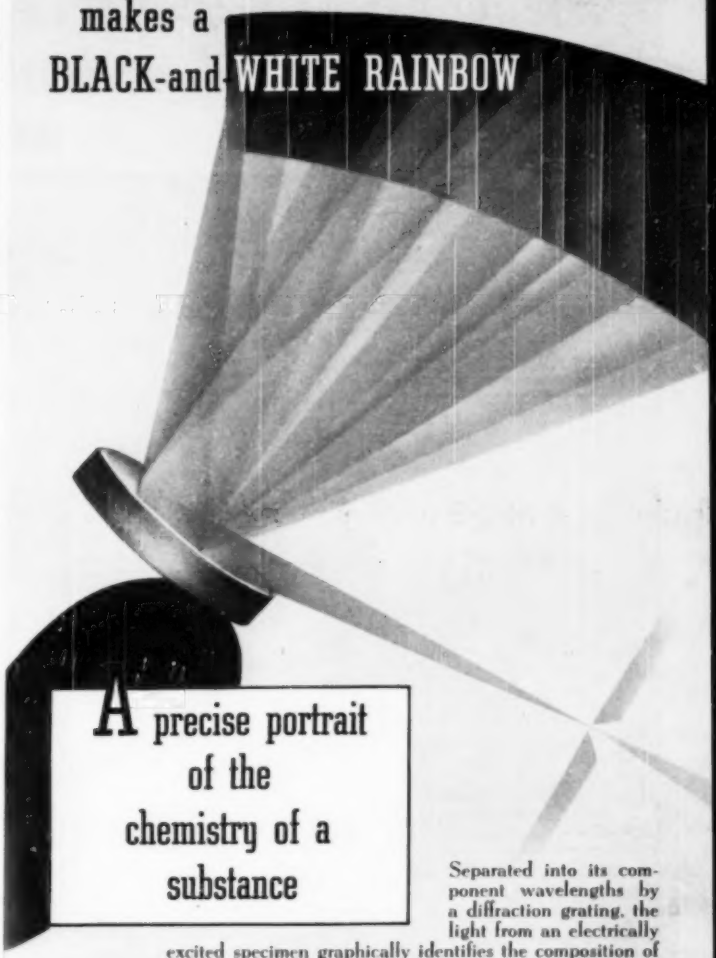
Send us, prepaid, a roll of your cloth for finishing. Try it under actual plant operations.

METROTEX, Inc.

Bayway Terminal Building
Elizabeth 2, N. J.

***Telephone:* Elizabeth 2-1352**

DIFFRACTED LIGHT makes a BLACK-and-WHITE RAINBOW



A precise portrait of the chemistry of a substance

Separated into its component wavelengths by a diffraction grating, the light from an electrically excited specimen graphically identifies the composition of inorganic compounds or alloys — for faster analysis in production control and industrial research.

The Baird Associates 3-meter Grating Spectrograph places complete control of this time-saving analytical method always at the fingertips of a single operator . . . with plate loading and all controls for grating and cassette within easy, arm's-length reach. Functional design conforms with the most modern laboratory organization and methods. Electrode holder is wholly enclosed — with interlocking switches to protect the operator. Universal specimen holder, Petrey stand, and water-cooled holder are interchangeable.

A 12-page booklet, Bulletin XXXII, describes in detail the Baird Associates Grating Spectographs, with illustrative photographs, charts, and diagrams. It will be sent on your request. Problems of specific applications will be gladly discussed by our engineers.

Baird Associates, Inc.

33 UNIVERSITY ROAD CAMBRIDGE 38, MASS.

*Other Services for CMH Flexible Metal Hose

VIBRATION

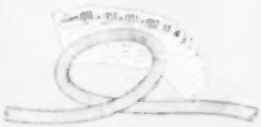
CMH Flexible Metal Hose absorbs vibration, isolating its damaging effects upon fixed structures.

MANUAL USE

For mobile service in conducting injurious media, CMH Flexible Metal Hose is the safe method.

MISALIGNMENT

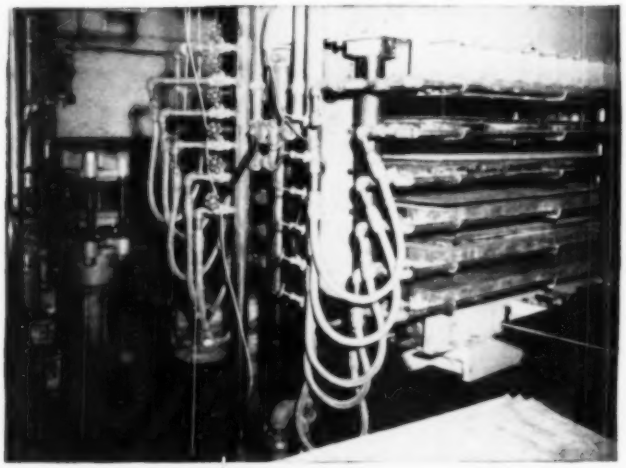
CMH Flexible Metal Hose is the simple, economical way to correct for misalignment, eliminating the need for complicated expensive hook-ups.



UNINTERRUPTED SERVICE

For installations requiring uninterrupted service, without repeated routine inspection, CMH Flexible Metal Hose is most dependable.

Where connections must withstand *heat and motion . . .



CMH REX-WELD Flexible Metal Hose

For services where the combination of *heat* and *motion* had made connections difficult to maintain, CMH REX-WELD Flexible Metal Hose is serving economically, dependably and safely. These all-metal assemblies, without packing, have long life free from leakage. There is no aging, deterioration or contamination.

CMH REX-WELD is furnished in steel or bronze in standard sizes from 3/16" through 4" I.D., with or without metal braid covering. Available with a choice of couplings to meet installation requirements.

Write for desired information . . . ask for detailed catalog data.

CMH—ONE dependable source for every flexible metal hose requirement

• CMH manufactures all standard types of flexible metal hose, both convoluted and corrugated, in a variety of metals; expansion joints for piping systems; stainless steel and brass bellows; various conduits and special assemblies of these components.

CHICAGO METAL HOSE CORPORATION

Leaders in the Science of Flexonics
MAYWOOD, ILLINOIS
Plants at Maywood, Elgin and Rock Falls, Illinois
In Canada: Canadian Metal Hose Co., Ltd., Brampton, Ontario
FLEXON identifies CMH products which have served industry for more than 47 years.

for every job...

TODAY THERE'S A BETTER WAY

collecting rainbow dust is profitable with DUSTUBE

At the National Lead Company in Los Angeles, American Dustube Collector solves the dust problem created in processing the finely ground, dry pigments that give Dutch Boy paints their vivid rainbow hues and lasting protection.

The clouds of fine dust caused by charging this material into the mixing machines represented a loss of valuable material. It made working conditions unpleasant, and would have created a public nuisance had the dust been discharged into the atmosphere.

The Dustube was selected because of its top efficiency in trapping the finest dust particles, and its low cost of operation and maintenance . . . it has lived up to every expectation. Cleanliness in the mixing room now makes quality control easier. No dust is discharged to the outside air. The men charge the mixers in comfort without respirators. The recovered pigments can be reused.

Challenge American's engineers to present an efficient and economical solution to your problem . . . as they have for thousands of others. An inquiry involves no obligation, of course.

The basic reasons for the high efficiency of Dustube Dust Collectors are described in this 54-page illustrated catalog. It contains valuable engineering data. Write for Catalog 72-A.

American WHEELABRATOR & EQUIPMENT CORP.
378 S. Byrkit St., Mishawaka 4, Ind.
OFFICES IN PRINCIPAL CITIES

dustube DUST COLLECTORS

LOOK TO WALKER PROCESS...

For the solution to your Water Works Problems

CAMP POROUS BOTTOMS

Bulletin 12S12

Water filter underdrain plates of crystalline fused alumina thoroughly bonded and kiln burned at a high temperature. Used in new and rehabilitated filters. Eliminates gravel and saves head room. Can be rehabilitated at will by acid treatment.

IRON FILTER

Bulletin 15I

Iron, manganese and gas removal by a simple backwashable two-stage contact filter. Combined iron and manganese removed to 0.1 ppm or less by one pass of the water through the contact media. Removal effected by autocatalysis of previous freshly formed precipitates.

FOR WATER SOFTENING . . . TURBIDITY AND COLOR REMOVAL . . . INDUSTRIAL WASTE TREATMENT . . .

The Clariflow

with independently-operated mixing, flocculation, stilling and sedimentation zones

A notable improvement over conventional short-retention water treatment units. Provides individual functioning of mixing, flocculation, stilling and sedimentation zones. • Its control over short-circuiting, control over each function and control of sedimentation through low weir rates mean improved effluent . . . higher filtration rates . . . longer filter runs . . . better industrial waste recovery and treatment.

Write for Bulletin 6S6

WALKER PROCESS EQUIPMENT INC.

EQUIPMENT • EQUIPMENT ENGINEERING

PROQUIP AURORA • ILLINOIS

CIRCULAR COLLECTOR

Bulletin 9S9

For all sizes of circular or square tanks. Collectors offered in two styles: the CT series (tractor drive on periphery of tank) and the CS series (suspended mechanism driven from a drive on tank bridge). Influent may be either siphon-feed or cross-pipe feed.

RECTANGULAR COLLECTOR

Bulletin 8S14

Chain type collectors for all sizes of rectangular tanks. Featured with these collectors are the torque tube drive shafts for the idlers. Helicoid or rectangular cross collectors may be used with these collectors.

FS FLOCCULATION

Bulletin 3S3

Mechanical flocculation employing staged zonal recirculation. A series of interlaced rolling actions are imparted to the water within the tank. Each floc particle is slowly and repeatedly brought into contact with the suspensoids, which are absorbed as the floc develops.

CARBONATION

Bulletin 7S7

Highly efficient water cooled type carbon dioxide producers. Carbon dioxide diffusers of the impingement type with 93% efficiency in gas absorption.

ENERGY MIX

Bulletin EM

Instantaneous blending of chemicals by the energy of incoming water. This unit should be considered with all coagulation problems.

RAPID MIXER

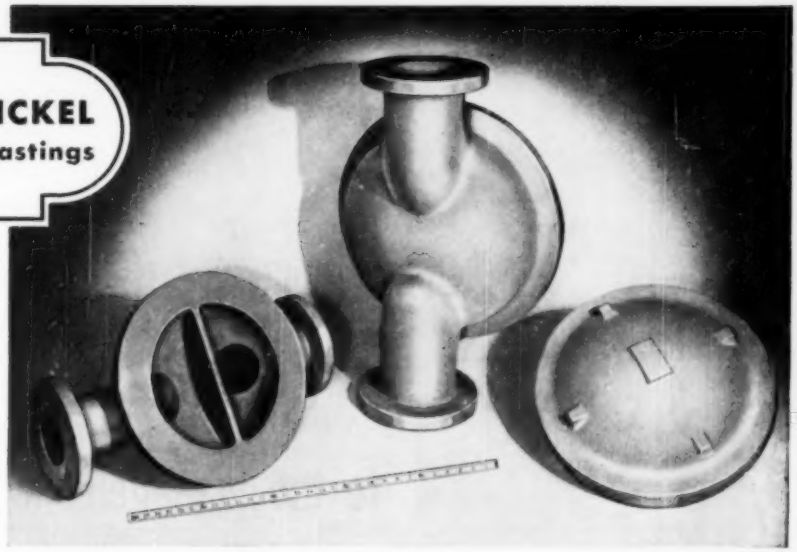
Rapid Mix units are offered for any mixing problem. A complete line of suspended, pivoted and staged mixers is available.

IMPINGEMENT AERATOR

Bulletin 17S31 and 37

A highly perfected and efficient aeration device for aerating liquids or inducing gas absorption. Gases are absorbed into liquids by higher absorption efficiencies than any other known aeration device.

99% NICKEL
Pressure Castings



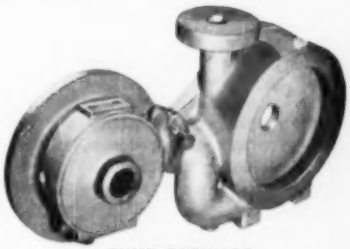
THE MEN OF *Stainless* -Recognized As Leaders in Casting STAINLESS STEEL

Now Offer You Equally Dependable Service in Casting . . .

MONEL - NICKEL - INCONEL

ANOTHER example of STAINLESS *pioneering* in the quality production of corrosion-resistant metals — the successful casting of pure nickel, monel, and inconel. *More* proof that when you refer your castings problems to STAINLESS specialists you may count on results that are consistently reliable.

BULLETIN *containing useful technical data sent upon your request.*



PUMP CASTINGS
Type 316
Stainless Steel

Stainless **FOUNDRY & ENGINEERING CO.**
5138 N. 35th St., Milwaukee 9, Wis.

District Representatives:

JOHN I. REID
Hilton, ROCHESTER, N.Y.
Phone Hilton 3674

HENRY A. SMITH CO.
261 Kent Road
Wynnewood, PHILADELPHIA, PA.
Phone ARdmore 6374

J. G. BURKE
1341 S. Boston
TULSA 5, OKLAHOMA
Phone 2-5726

One of a series of messages to help you increase your understanding of business paper advertising, and its effect on your job.

Does your advertising manager rate an invitation to the management table?

IF YOU SHOULD ASK *him*, he'd probably say "yes." And his reasoning might run something like this:

Management's first responsibility is to show a fair profit. This requires a relentless search for continued improvement – in design, in purchasing, in production, research and cost-accounting. Each deserves its place at the management table. Yet none of these activities can actually create a dollar of profit, for the simple reason that you can't *produce* anything at a profit – not unless you can also *sell* it.

And that's what makes the advertising manager's job so important.

His first responsibility is to see that your company's products are made familiar (and desirable) to the greatest number of prospects, at the lowest possible cost. In fulfilling this responsibility, he sets a parallel course with the sales department, although his approach more closely resembles that of the assembly line technician.

For advertising, as he sees it, is simply the application of assembly line techniques to the *manufacture of a sale*. Just consider the five basic steps involved:

1. **Seeking out prospects**
2. **Arousing their interest**
3. **Creating a preference for your product**
4. **Making a specific proposal**
5. **Closing the order**

By *mechanizing* the first three of those steps, advertising increases management's chance to show a profit. It leaves your salesmen free to concentrate on the two jobs which they alone can do, and do best.

And nowhere does this mechanizing process operate more efficiently than in the business press, where it reaches your best prospects at the lowest possible cost.

Perhaps that's why so many smart advertising managers are partial to business paper advertising – and why more of them, incidentally, are getting to sit at the management table!

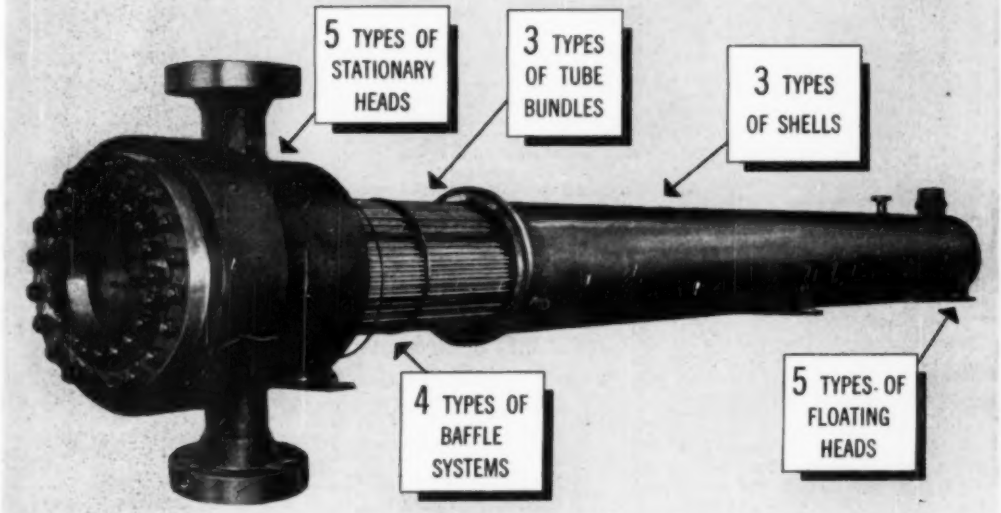
CHEMICAL ENGINEERING
With Chemical & Metallurgical Engineering
A McGraw-Hill Publication
330 West 42nd Street New York 18, New York

THE ASSOCIATED BUSINESS PAPERS
205 East 42nd Street, New York 17, N. Y.

ABP's BUSINESS IS TO BOOST YOUR BUSINESS

Modern Designs in Tubular Exchangers

A type for every requirement in the chemical industries



G-R has available this wide variety of arrangements to provide an exactly suitable combination for every tubular heat exchanger requirement.

From G-R, too, you can obtain special features such as the G-R Pass Partition Sealing Plate which makes use of the pressure differential between tube passes to prevent leakage between passes, the G-R Floating Head Split Ring Joint which enables a larger removable tube bundle containing more tubes to be used in a shell of given diameter, and the G-R "Breech Block" Head which eliminates the necessity of heavy bolts to maintain tightness of the joint between the head and cover on high pressure service.

These and other G-R features are the result of more than 80 years of experience in specializing on the design of heat transfer apparatus. This experience is at your service in assuring greatest effectiveness, most dependable operation and lowest maintenance expense of condensers, coolers, heaters, and heat exchangers for your particular needs.

Write for Bulletin 916 describing G-R Tubular Exchangers in detail.

THE GRISCOM-RUSSELL CO., 285 MADISON AVE., NEW YORK 17, N. Y.

GR-329

GRISCOM-RUSSELL

PIONEERS IN HEAT TRANSFER APPARATUS

SOLVENT VAPOR DRYING PROCESS DRIES WOOD IN HOURS WITHOUT DETERIORATING EFFECTS

Heretofore wood has been dried in open air, by steam, or by high temperature air. Open air drying takes 6 to 18 months; steam and high temperature air often result in hydrolysis or burning. Now, one of the country's largest wood preserving plants has developed a Vapor Drying process which safely and effectively dries wood in from *6 to 14 hours!* The drying agent used is *Esso's Solvesso Xylol.*

The drying process begins when a locomotive pushes a charge of crossties, approximately 100 feet long, into a cylinder or drying chamber. At the proper time, vaporized Solvesso Xylol is passed into the drying cylinder. The hot Solvesso Xylol vapor is circulated through the cylinder for a few hours, penetrating many inches into the wood and evaporating much of its moisture.

As "dry cleaning" and moisture evaporation continue, the solvent vapor with its moisture-lignin content leaves the cylinder and is condensed, separating the solvent from the water in the settling tank and returning the Solvesso Xylol to the evaporator to be reused. (see diagram)

5 Gallons of Water from One Crosstie

The amount of water removed from the settling tank determines the relative dryness of the wood being treated. When drying is finished, the Solvesso Xylol lines are closed, the chamber evacuated and the wood is ready for treatment with wood preservative. Water from the settling tank is passed through a meter, which is read periodically to determine wood drying progress. One charge of 800 crossties may be made to give up as many as 4,000 gallons of water—*or 5 gallons per crosstie*—in a 12-hour drying period.

Esso Solvents Play Vital Role in Scores of Industries

Rubber, textiles, chemicals, paper, food, leather and scores of other industries are utilizing the many types and grades of solvents manufactured by Esso Standard Oil. Production men know they can rely on Esso Petroleum Solvents' purity and uniformity, maintained through most modern and stringent refinery treatment. If you have a solvents problem, let our technical men examine your requirements and determine the solvent best suited to your needs. Drop a line today to our office nearest you.

Paper Mill Machinery now Cleaned with Solvesso 100

Solvesso 100 is now being used to clean paper machine screens and felts when they become congested with natural wood pulp gums and resins. Since paper machines are operated at extremely high temperatures, Solvesso 100's high flash point (over 100°F.) makes it ideally suited. In addition, Solvesso 100 has especially high solvency for resins since it contains more than *95% petroleum aromatics.*

Before they were creosoted, the crossties in this picture were dried by a new vapor process employing Solvesso Xylol.

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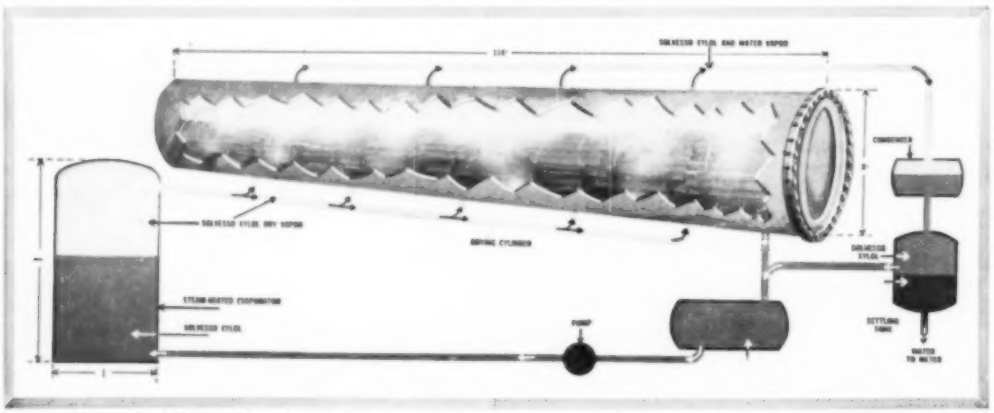

This diagram shows how Solvesso Xylol is being used in new vapor drying process for drying crossties.

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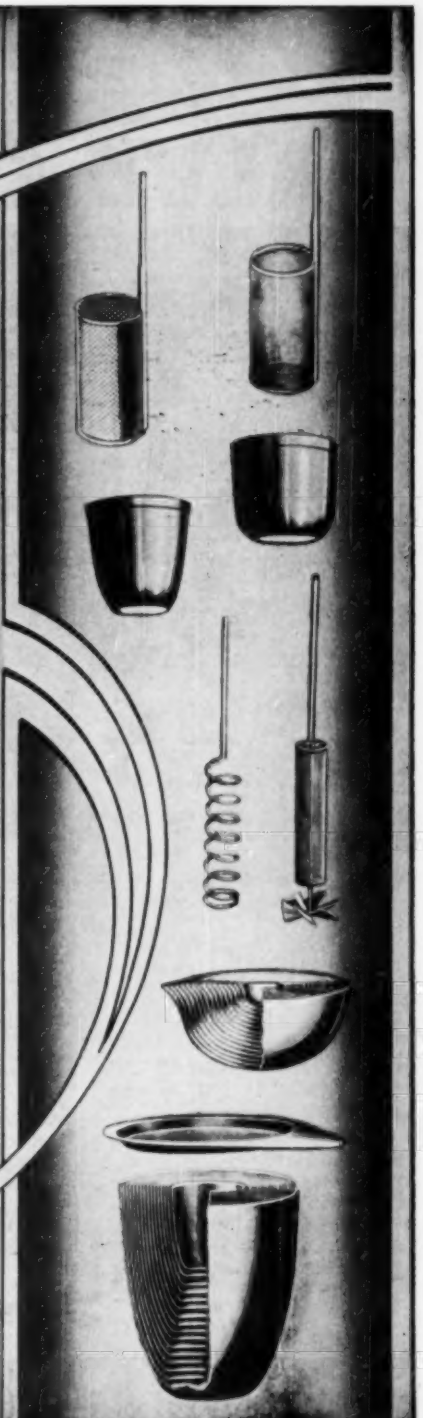

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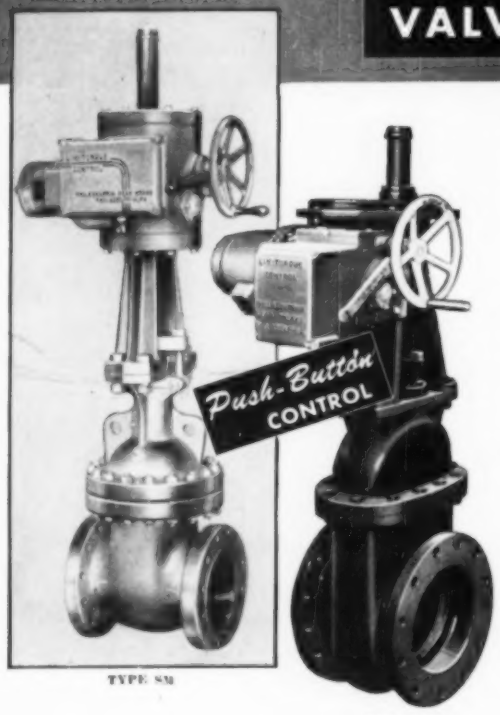

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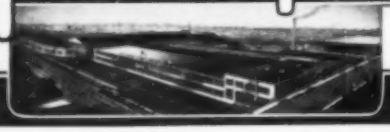

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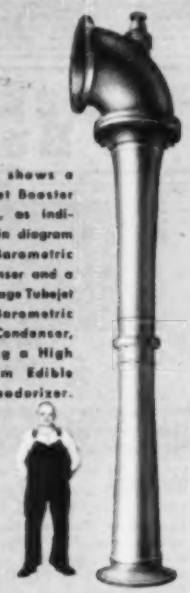
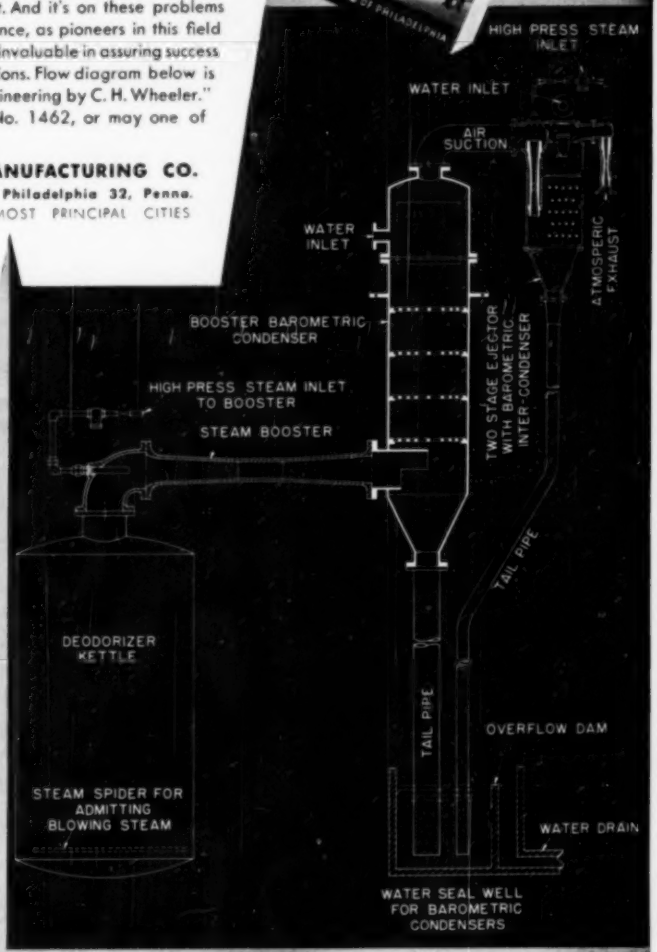


Photo shows a Tubejet Booster Ejector, as indicated in diagram with Barometric Condenser and a Two Stage Tubejet with Barometric Inter-Condenser, serving a High Vacuum Edible Oil Deodorizer.



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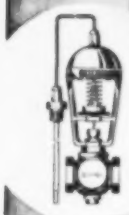

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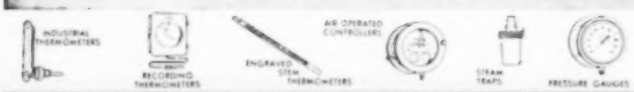

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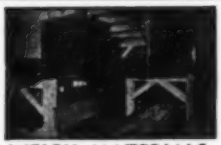

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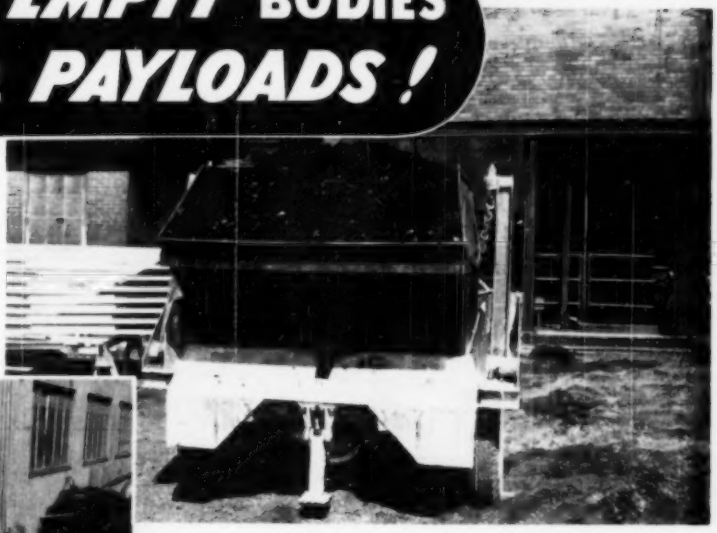
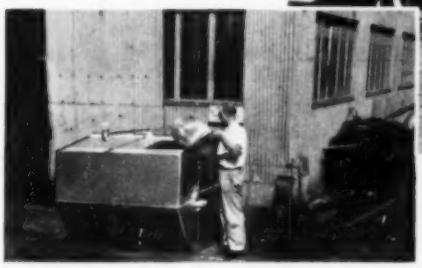


This Load Lugger-equipped truck was busy on another mission when the pulp was being loaded.



Liquid-tight garbage type bodies are used to collect waste paper, ice cream cups and trash that is thrown down by employees going into the plant.

Slag collected at the bark-burning boiler and fly ash from the stacks is about to be dumped into a nearby fill. This is start of dumping operation. All controls are handled by the driver in the cab.

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One Load Lugger and 29 detachable truck bodies replaced 5 trucks and 13 men in this Louisiana plant—eliminated unnecessary re-handling of materials and time wasted by loading crews and drivers. Monthly savings in labor alone (2080.47 man hours) paid for this equipment in record time. All bodies are pre-loaded at the various collection points—*as the materials accumulate*—waste lime at the pulp mill, chemicals at the alum plant, fly ash and slag at the power house, shivers and bark under the wood conveyor, sawdust at the carpenter shop, refuse in the yards, etc. One man, the driver of the truck equipped with the Load Lugger hoisting unit, handles everything—picks up a loaded body, hauls and dumps it, or relocates the load. Four types of bodies were designed to handle over 15 materials for this plant.

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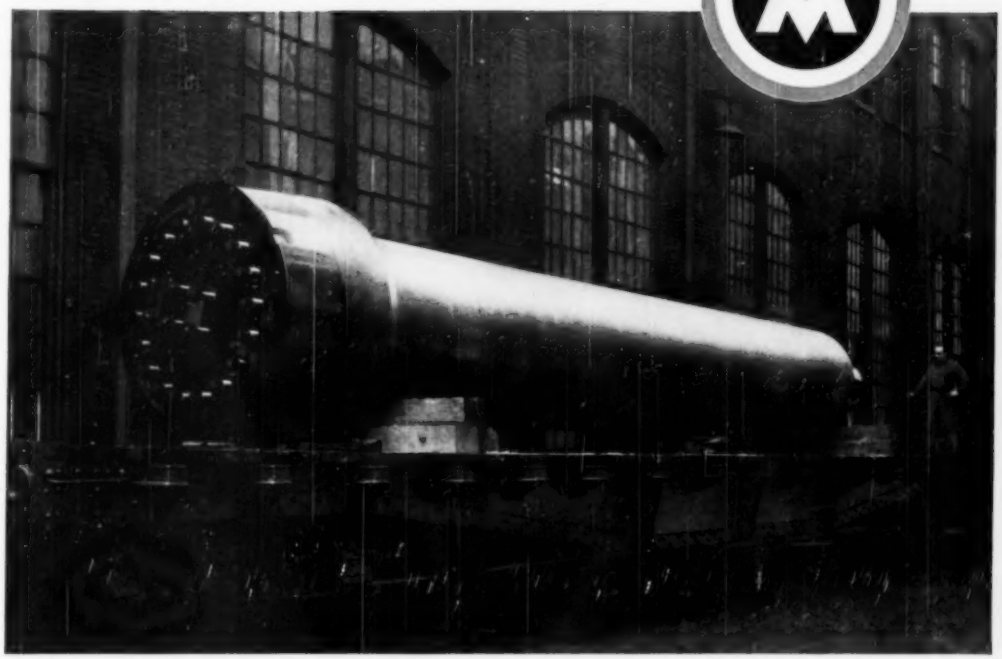

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3. **Creating a preference for your product**
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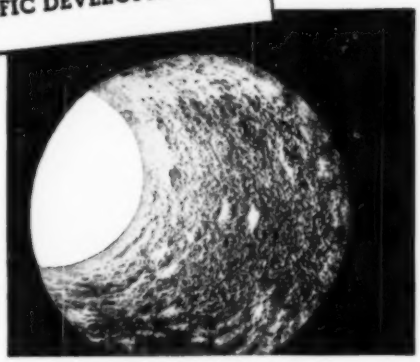
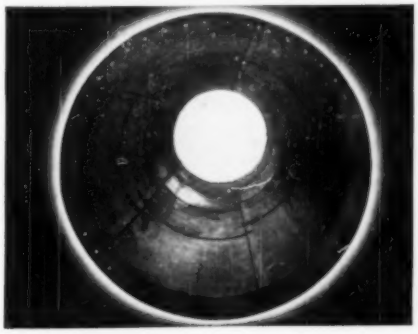


A feast for acids . . .

(PIPE IMPROPERLY LINED)



a famine for acids

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2—Copper Vac. Kettles, Jkt'd, agit, 100 gal.

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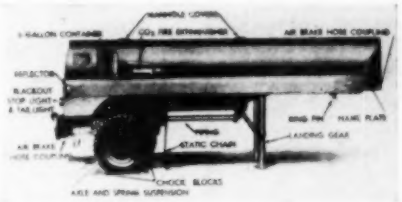

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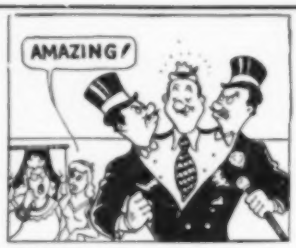

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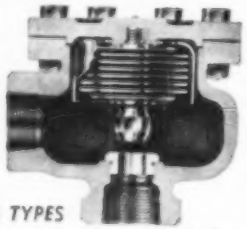

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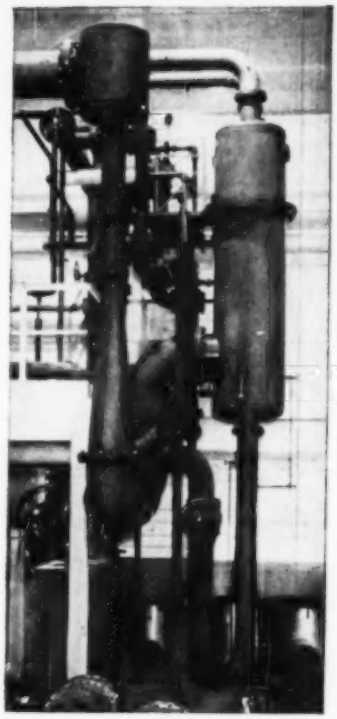

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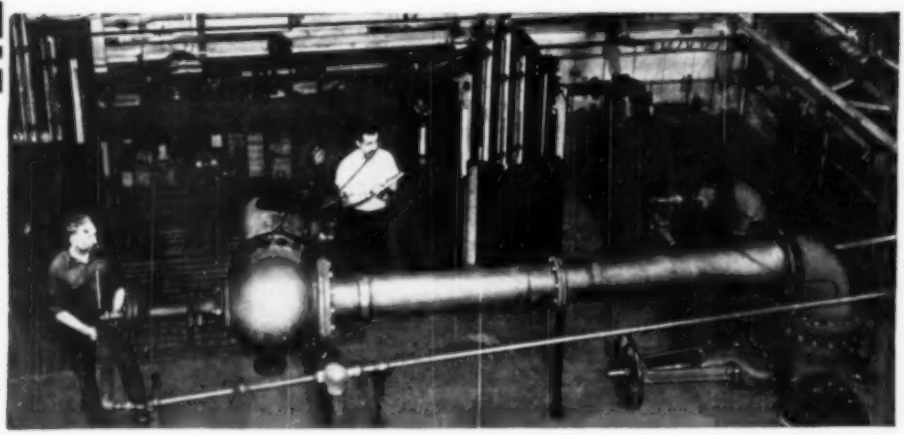

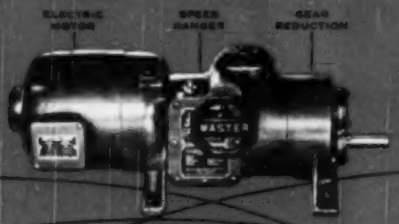

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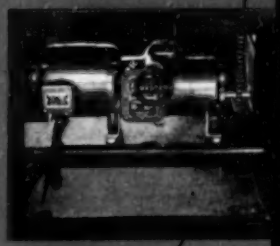

The all-metal construction of Master Speedrangers adds greatly to the compactness and durability of the job.

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Standard Pfaudler Heat Exchangers

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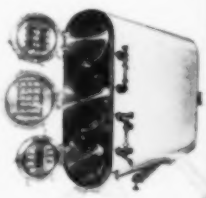
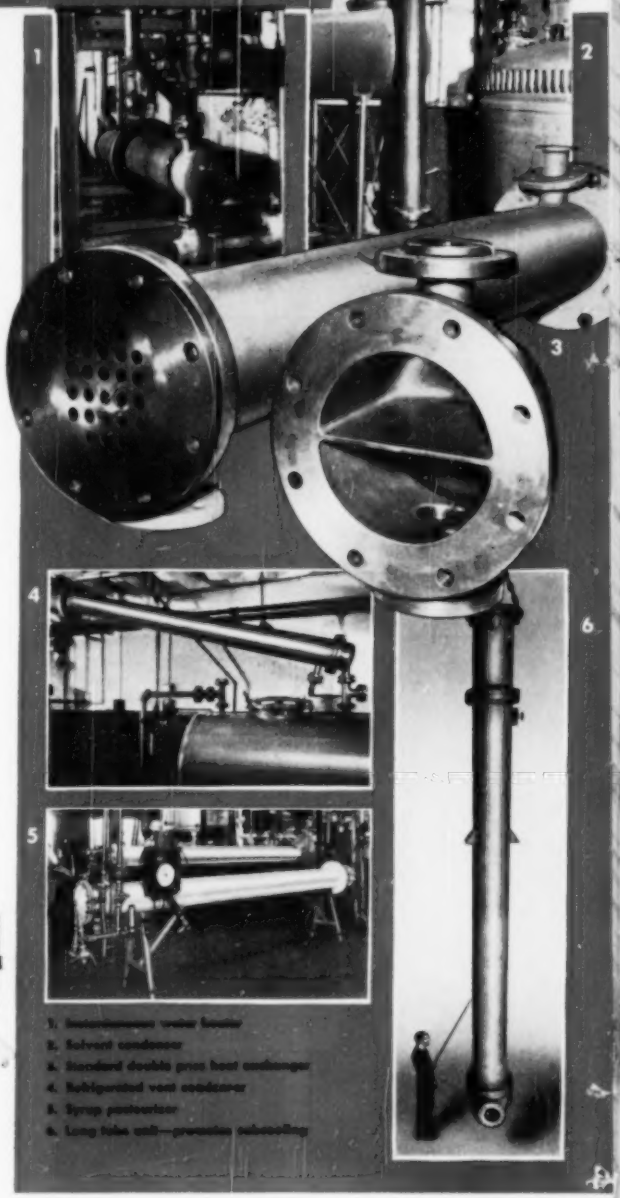
1. Built to rigid engineering tolerances, ASME Code U-69 construction (or API-ASME when required). Metal thicknesses exceed code requirements. For example, tube sheets have minimum thickness equivalent to diameter for good roller expanded joints.
2. Design pressures—full vacuum, 75 and 150 psi.
3. Shell diameters—4" to 24" nominal size.
4. Tube sizes—⅜", ¾", and 1" O.D.
5. Single or multipan tube flow.
6. Exclusive Pfaudler "snap-ring" type of one-piece backing ring construction for removable tube bundles.
7. Loose flange construction (van-stoned type) for ease of assembly and the avoidance of liners.



Combination heater, cooler and refrigerator for syrup



Pfaudler

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